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**FORGING INDUSTRY LEADTIMES:
AN ANALYSIS OF CAUSES FOR AND SOLUTIONS TO
LONG LEADTIMES FOR AEROSPACE FORGINGS**

THESIS

**Stephen F. O'Neill, B.A.
Captain, USAF**

AFIT/GLM/LSP/86S-55

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**FORGING INDUSTRY LEADTIMES: AN ANALYSIS OF CAUSES FOR AND
SOLUTIONS TO LONG LEADTIMES FOR AEROSPACE FORGINGS**

THESIS

**Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology**

Air University

**In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management**

Stephen F. O'Neill, B.A.

Captain, USAF

September 1986

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Abstract

Leadtimes for aerospace forgings exceeded two years in some cases between 1979 and 1981. While current leadtimes are not this long, there remains concern over the leadtimes for forgings and the forging industry's ability to respond to increased demand in a timely manner. A review of literature pertaining to this topic was conducted and is included in this report. Possible problems and/or causes responsible for long forging leadtimes, and possible solutions to long forging leadtimes, were identified from the review of literature. Interviews were conducted, concerning the identified problems and solutions, with forging firms, forging industry officials, raw materials processors, USAF personnel (active duty and civilian), and Department of Commerce personnel. The results of those interviews and conclusions drawn from them concerning the identified problems and solutions are presented.

FORGING INDUSTRY LEADTIMES: AN ANALYSIS OF CAUSES FOR AND SOLUTIONS TO LONG LEADTIMES FOR AEROSPACE FORGINGS

I. Introduction

Problem

The production cycle on many Department of Defense (DOD) systems has become excessively long over the last ten years. The leadtimes (time of ordering to time of receipt) for many systems is in excess of two years and in some extreme cases has approached four years. These long leadtimes are a major concern because they can lead to increased system cost and, more importantly, they may severely limit DOD's ability to rapidly increase military production should a conflict or other national emergency require it.

One specific factor that contributes to excessive system leadtimes is the excessive time to procure the various subsystems which make up DOD systems. These subsystems are in turn held up by the time to receive the various components of which they are constructed. And finally, the components themselves are held up by the time to receive the raw materials of which they are constructed. It is a snowball effect, in that any delay in a lower tier of this production hierarchy carries through to the higher levels. A delay at a lower level cannot be made up for once it has occurred. Therefore, for any effort to be successful in reducing overall system leadtime it must first be aimed at the lower tiers of the hierarchy. In the case of this study, the excessive time required to procure forgings, at the component level, will be addressed. This one type of component often has delivery times in excess of two years.

Objective of Study

There are four general objectives to be accomplished by this study.

They are:

- 1) Determine and define the current condition of the forging industry in relation to leadtimes for aerospace products.
- 2) Determine and define the probable causes responsible for past and present long leadtimes.
- 3) Determine, explain, and evaluate some possible solutions to causes of long leadtimes, both past and present.
- 4) Determine the causes for, or actions responsible for, current leadtimes.

Are current leadtimes a result of action being taken to correct the proposed problems and/or causes and to implement the proposed solutions, or are they the result of purely market forces?

By successfully accomplishing these four major objectives, any efforts to reduce forging component leadtimes, and ultimately overall system leadtimes, will be better able to focus on the appropriate areas. This focus should increase the efficiency and effectiveness of these future efforts.

Scope and Limitations

This study of forging leadtimes will be directed toward that portion of the aerospace forging industry which has the longest delivery times, and therefore, the most severe impact on total system procurement, specifically, forgings of large physical size and those made of specialty metals and super-alloys. Examples of large forgings are airframe structural members such as wing spars, pylons, and landing gears. Specialty metals and super-alloys include titanium, and the aluminum and stainless steel alloys dependent on cobalt and chromium as alloying agents. These are used

primarily for internal jet engine components. These large forgings and specialty metal forgings, while a very small percentage of total forgings, are the vital few which cause the majority of problems and, therefore, require the most attention.

The scope of this research was reduced to the larger forgings and specialty metal forgings. By doing so the population dropped from approximately 400 firms in the total industry to approximately 40 firms involved in aerospace work. It was determined that due to the subjective nature of the information being sought, interviews would be the best form of gathering data. With the population reduced to 40 firms, the researcher was easily able to visit and interview a representative number.

II. Literature Review

Information Sources

The information obtained, and used to produce this review, consisted of three major studies (one by a civilian firm, one by a DOD organization, and one by the U.S. International Trade commission), articles from periodical literature, books, pamphlets, hearing briefs from the international trade commission, trade association publications and position papers. The first major study is entitled Analysis of Critical Parts and Materials, was commissioned by the Air Force Business Management Research Center located at Wright-Patterson AFB, Ohio, and was published in December of 1980. It looked at leadtimes, their causes, and possible solutions, for five sectors of the aerospace industrial base: forgings, castings, bearings, connectors, and integrated circuits. The study was done by a private firm, the Analytic Sciences Corporation, of Arlington, Virginia. It was a specific and comprehensive data source and formed the backbone of this review. However, it is now over five years old. The second major study was the Blueprint for tomorrow study done by the Aeronautical Systems Division of Air Force Systems Command and published in January of 1984. It was a joint effort between Air Force and industry to assess the entire aerospace industrial base. It is one of the most current sources of information, but suffers from the fact that it mixes forging information in with other sectors of the aerospace industrial base. Therefore, its primary value was limited to being updated support for the specific information in other sources. The third major source was the U.S. International Trade Commission's Competitive Assessment of the U.S. Forging Industry. It was the most up to date source

of information and contained a broad base of industry statistics. It was published in April of 1986.

The periodical literature consisted of articles covering the problems caused by forging leadtimes in the 1979-1981 time frame. It was very specific and valuable but its limitation is that it was generated only during the very worst periods of forging leadtime delays. Periodical literature on forging leadtimes all but ceased to exist after 1981. The last major source of information was the industry trade associations, specifically the Forging Industry Association (F.I.A.) located in Cleveland, Ohio. This organization represents approximately 85 percent of the North American forging capacity (United States and Canada) (17:1). The information obtained from F.I.A. varied in age from four to five years to only a few weeks and included the forging process, papers presented to the International Trade Commission, and position papers responding to allegations concerning forging leadtime problems and their causes. F.I.A. information was very specific and contained a large amount of valuable industry statistics.

Overview

This report will begin by giving a general description of the forging industry, to include, the number of firms, sales, employment, etc. Next, it will cover specific leadtime data such as, how long, the systems impacted, and the production surge in the late 1970's which focused attention on the industry initially. It will then address some of the reasons, or probable causes, for long forging leadtimes. And finally, some proposed solutions to the probable causes will be identified and discussed.

Industry Profile

The forging industry (U.S. and Canada) consisted of approximately 350 firms in 1980 according to the Forging Industry Association (F.I.A.) (18:9). F.I.A. estimated the labor force to be around 80,000 (18:9). Total sales for the industry in 1980 were estimated at 6.3 billion dollars (18:9). The DOD share of this market was, and is, fairly small. Of the estimated 350 firms in operation in 1980, only 40, according to F.I.A., were in the aerospace forging business (17:4). This works out to slightly less than 12 percent of the forgers doing any aerospace business at all. In dollars, DOD's share in 1980 was 750 million of the 6.3 billion in sales, just under 12 percent of sales (17:7). DOD's share, by volume, of the entire industry, aerospace and non-aerospace, in 1977 was only 2.5 percent (15:6-4).

According to F.I.A., in a brief to the International Trade Commission on 13 January 1986, the average firm is a small business with less than 125 employees and total sales of less than 15 million dollars annually (3:6). Forgers doing DOD business do not fit into this average category; they are the exception to the rule. The Aeronautical Systems Division, in its 1983 study Blueprint for Tomorrow, pointed out that a small number of forgers are common to the entire aerospace industrial base (1:3-9). In fact, in 1980 there were only three firms with total DOD related contracts in excess of 25 million annually (15:B-13). DOD is, therefore, nearly totally dependent on a small number of large aerospace forging firms.

Even though the general economic condition of the forging industry is not good and has been declining since the early 1980's, some think leadtimes are still too long and the DOD cannot get what it needs in a timely manner. F.I.A. states that production, employment, profitability, and capacity utilization have all fallen since 1981 (3:1). F.I.A. sampled 40 forgers in 1985

and received the following information concerning sales and profits among the 40 firms: net sales from 1981 to 1983 were down 38 percent from \$697 million to \$430 million; they were back to \$557 million in 1984 but this was still 20 percent below the 1981 level (3:4). The U.S. International Trade Commission's (USITC) April 1986 report Competitive Assessment of The U.S. Forging Industry came up with almost identical percentages. The USITC net sales figures for Aluminum, Titanium, and high temperature alloy forgings from 1981 to 1984 were down from \$1.2 billion to \$744 million, or 37.77 percent (Figure 1) (48:19). Profit and profit percentage has also declined with sales. In 1981 the F.I.A. sample of 40 firm's profit was 10.2 percent of sales, by 1983 it was a 1.6 percent loss, in 1984 it was back to only 3.2 percent of sales, and finally, after three quarters of 1985 it was still less than 3.5 percent of sales (3:5). The USITC report also discussed profit and profit margins, but differed slightly with what the F.I.A. had to say. The USITC Competitive Assessment Of The Forging Industry reported total profit for aluminum forgings to have decreased from 8.3 million dollars in 1981, to a loss of approximately 6.0 million dollars in 1983 and back up to a loss of 1.9 million dollars in 1984. Its figures for titanium and high temperature alloy forgings show a decrease in profits from approximately 170 million dollars in 1981 to approximately 96 million dollars in 1984 (Figure 2) (48:19). The USITC reported that from 1981 to 1984 profit margins for producers of aluminum forgings fell from 3.2 percent to a 1.2 percent loss. However, the USITC also reported that for the same time period, 1981 to 1984, producers of titanium and high temperature alloy forgings saw their profit margins only decrease from 18.3 percent to 16.3 percent (Figure 3) (48:19). The answer as to why DOL cannot get enough production out of an industry that is begging for business, is summed up in a statement from the

Analysis of Critical Parts and Materials study:

The majority of suppliers are not exclusively in the military aerospace business, indeed many deliberately minimize their dependence on defense business and maximize their revenue and orders from commercial customers (15:1-3).

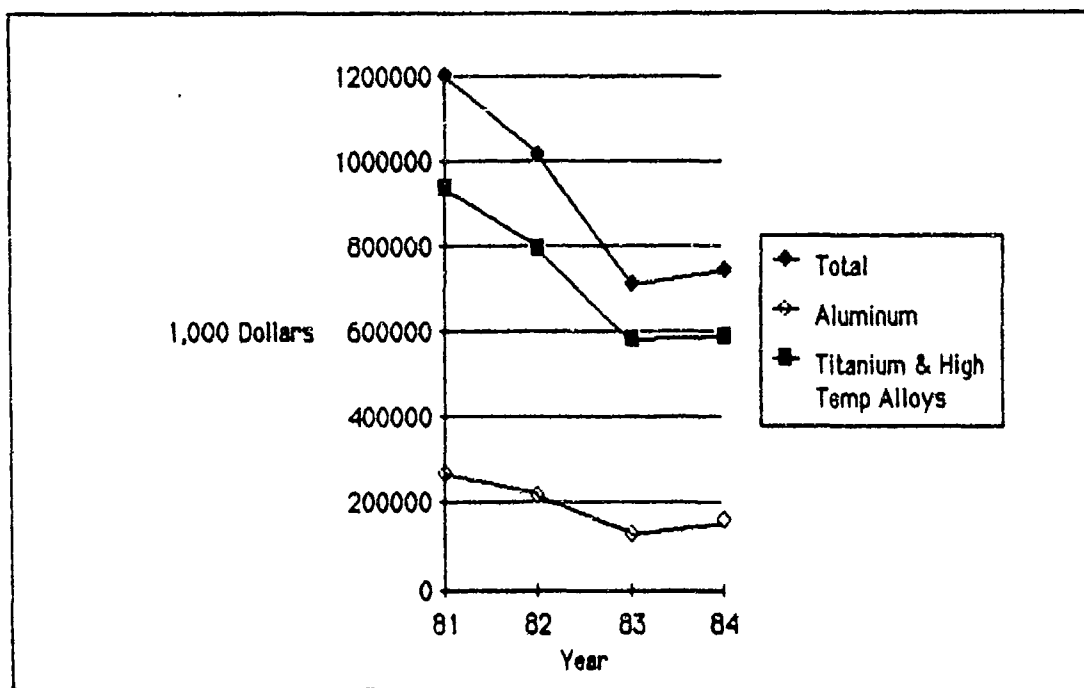


Figure 1. Net Sales: Aluminum, Titanium,
& High Temp Alloy Forgings
Adapted from USITC figures (48:19)

To sum up the profile of the forging industry, it is an industry made up of small businesses, most of which do not do DOD business. Those that do are exceptions and consist of a small group of the largest firms. DOD business is still a small part of these firm's business and they, therefore, do not depend on or make long range plans based solely on DOD needs. The industry is very sensitive to, and driven by, the business cycle. Therefore, even large percentage increases in DOD orders have little effect on the industry as a whole and leadtimes continue to be excessive.

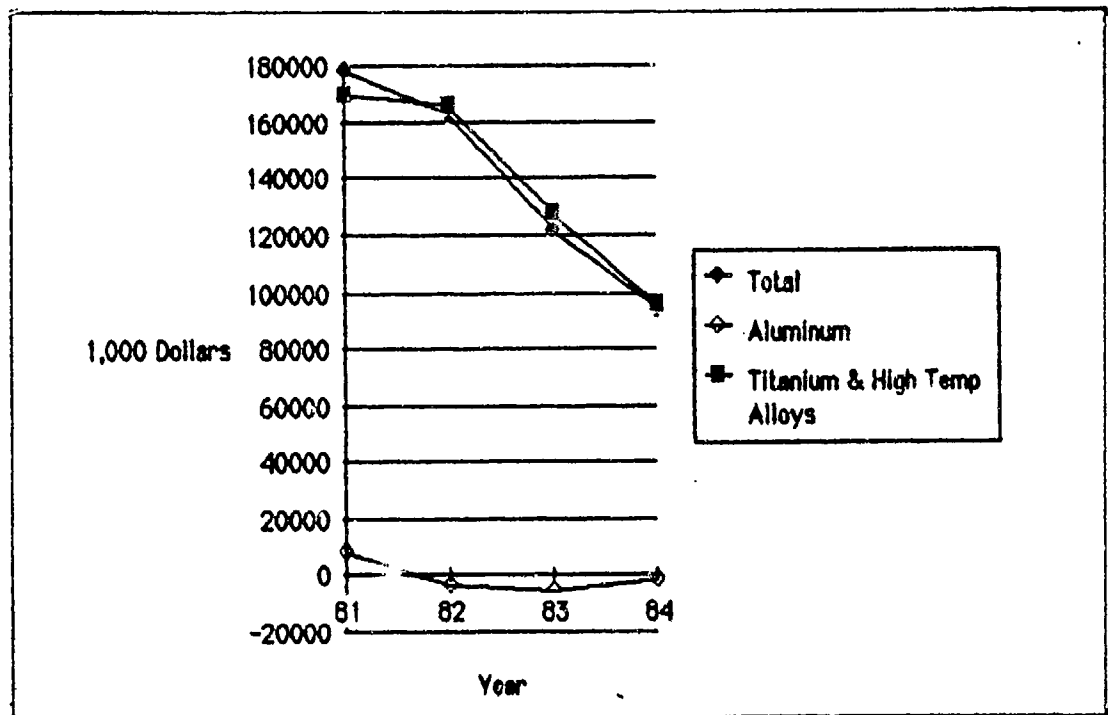


Figure 2. Net Profit & Loss: Aluminum, Titanium, & High Temperature Alloy Forgings
Adapted from USITC figures (48:19)

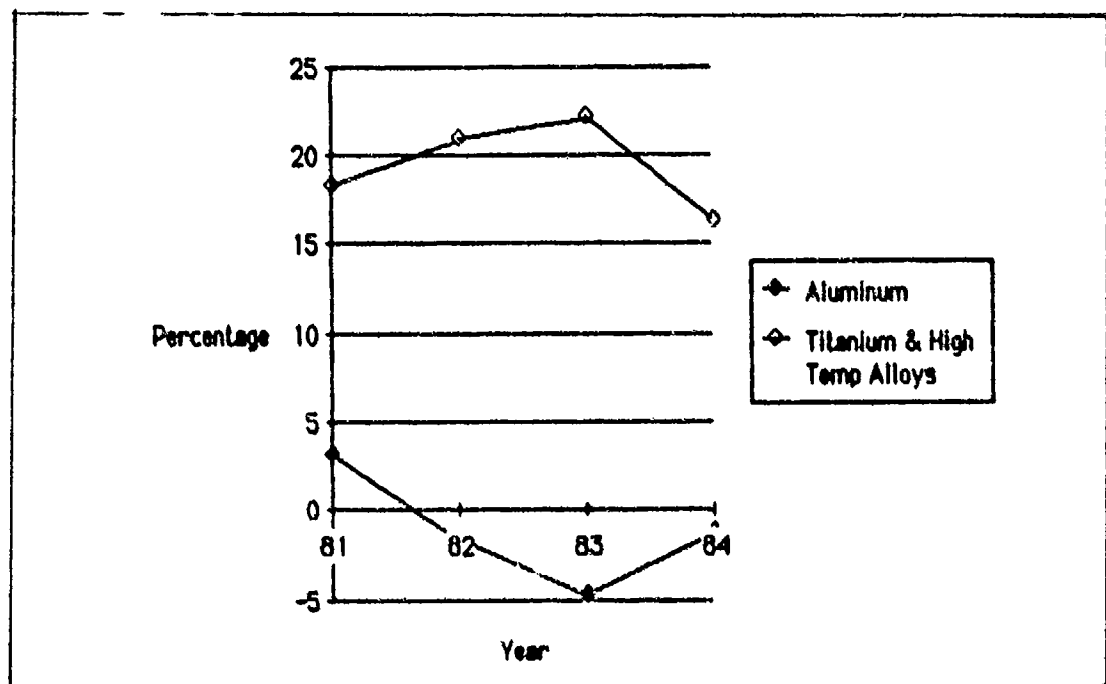


Figure 3. Profit Margins: Aluminum, Titanium, & High Temperature Alloy Forgers
Adapted from USITC figures (48:20)

Impact of Leadtimes

In this section leadtime will be defined and explained, specific examples of excessive leadtimes will be given, and the impact leadtimes have had, and are having, on certain aerospace systems, will be shown. F.I.A. defines leadtime in forging as follows:

Quoted "leadtimes" are a forging company's carefully planned "time frame" to obtain needed materials, schedule production, and forge, inspect and ship parts. Should new tooling be required the leadtime could be longer to reflect the time needed for tool design, die sinking, and production pretesting (18:2).

Another definition is the time required to accomplish the following six tasks in the forging process: 1) secure raw material 2) prepare that material 3) heat and actually forge it 4) performing various post forging activities such as heat treatment and machining 5) quality control testing and inspection, and finally 6) packaging and shipping (18:2).

Leadtime can be further broken down into production leadtime and queue leadtime (15:6-5). Production leadtime is the time required to produce the forging once the raw material is on hand and physically begins the production process. Queue leadtime is the time required to receive the material before processing can begin and the time that it waits for other material to be processed ahead of it. The general impression of the literature reviewed is that this latter type, queue leadtime, has been, is, and will be for the foreseeable future, the primary problem area. The Analysis of Critical Parts and Materials study pointed out that over 50 percent of leadtime in 1980 was queue leadtime (15:6-5). The primary causes of this type of leadtime are materials shortages and lack of production capacity.

Just how bad have leadtimes been? Between 1977 and 1980 the

industry wide average leadtime for aerospace forgings more than doubled, increasing from 11 to 26 months (15:5-15). That was a 136 percent increase in leadtime for aerospace forgings. But that was only an average; it was quite often much worse for specific manufacturers or products. Wolfgang H. Demisch, then an aerospace analyst for Morgan Stanley & Company, made the following assessment in a May 1980 Business Week article, "Forgings are the single most blatant item of shortage in aircraft manufacturing"(49:40J). In February of 1980, Parker Hannifin Corporation, which manufactured main flight controls for the F-16 and F-18 fighters, had to order its forgings 60 to 80 weeks ahead. This extended that company's leadtime to deliver those flight controls to General Dynamics, McDonnell Douglas, and Northrup to over two years (41:3). Even worse was the case of Wyman-Gordon, the nation's largest DOD aerospace forgings supplier. In 1979 the company's total sales were 427 million dollars and in 1980 they had a backlog of work that exceeded one billion dollars. This can be compared to their 1977 backlog of only 270 million dollars (49:40J). Wyman's leadtime to deliver forgings was reported by Business Week, in May of 1980, to be running at 100 weeks (25 months) or more (49:40J).

Now lets look at specific DOD systems which were either paced by (Paced simply means that that item was the one single longest leadtime item for the entire system.), or severely hampered by, long leadtimes for forgings. The Analysis of Critical Parts and Materials study looked specifically at thirteen individual aerospace systems. Of these thirteen, six were paced by a forged component (15:5-8). These systems were the A-10, F-16, and F-15 fighters, the E-3A aircraft, Laser Guided Bomb, and the B-52 Offensive Avionics System/Cruise Missile Integration system (OAS/CMI) (15:5-8). In 1983, ASD's Blueprint for Tomorrow study also listed the F-16 and F-15 as

well as the Navy F-14 and AV-8 Harrier fighter aircraft as being constrained by forging leadtimes (1:4-9,4-10).

The A-10 was the worst case of the aircraft mentioned above. In 1980 the leadtime to receive landing gear for the A-10 was at 46 months, almost four years. The primary component of this landing gear was a forging, produced by Wyman-Gordon, which had a leadtime of between 28.5 and 33 months (15:4-16, 41:83). Wyman-Gordon's North Grafton, Massachusetts plant that produced this forging was a government owned and contractor operated (GOCO) plant. Only 38 percent of the business Wyman-Gordon did in that plant was DOD business (15:4-16). The other 62 percent of the orders processed in that plant were commercial orders and were weighted equally, on a first come first serve basis, with DOD orders (15:4-16).

As mentioned, forgings were also the pacing items on the F-15 and F-16 fighters in 1980. The F-15 requires 6,778 forgings per aircraft (16:1). It's longest leadtime forging was an F-100 engine forging, a Wyman-Gordon product, which took 36 months to receive (15:4-19). The F-16 fared no better in 1980 with three separate pylon forgings, taking 38 months each to receive (15:4-20).

The leadtimes for forgings on other systems mentioned above, while not as severe, were still excessive. The B-52 OAS/CMI was paced by a 21 month forging (15:4-22). The E-3A aircraft was paced by a 17 month forging (15:4-29). And last, the Laser Guided Bomb was paced by a nine month forging (15:4-13).

1979-1980 "Crunch"

One area which needs to be mentioned separately, before discussing

the probable causes of long leadtimes, is the "79-80 crunch". During this short period of time a combination of factors came together to create excessive leadtimes for almost all aerospace forgings for both DOD and commercial customers. These factors were an all time high demand for new large commercial aircraft, and a shortage of specialty raw materials such as titanium, cobalt, and chromium. F.I.A. summed the "crunch" up as follows:

During the 1979-1980 commercial and military airplane build surge, there were long forging leadtimes for aerospace forgings. Extended leadtimes for titanium and stainless aerospace forgings in 1979-1980 were directly traceable to a critical shortage of titanium and chromium, cobalt-bearing steel and super alloys (alloying agents for stainless jet engine parts) not forging capacity or capability (18:3). Because of the materials shortages, forgers had to wait 12 months just to get needed material. So as a result, there were instances where it took 18 months to obtain materials, forge, and ship certain aerospace forgings (18:3).

This last statement by F.I.A. was somewhat optimistic, as the 36 to 46 month leadtimes on the A-10, F-15, and F-16 illustrate, but the basic cause is accurate. There was an extreme raw materials shortage which, when combined with an all time high in large aircraft production, made for a forgings shortage the equal of which had not been seen before. The aircraft production increases were mostly in the commercial market due to a desire for more fuel efficient designs to combat the energy crisis. In 1977 commercial aircraft production was 4.7 billion dollars and by 1980 it had increased to 12.7 billion (49:40j). The "crunch" ended in 1981 as commercial aircraft production declined and the raw materials shortage lessened. This is reflected by the fact that orders for commercial aircraft production were 50 percent of all aircraft production in 1979 but by 1983 this had fallen to 33 percent (1:E-4).

Probable Causes/Problems Responsible for Long Forging Leadtimes

The factors and problems mentioned in the literature on forging leadtimes as being responsible for long leadtimes are quite numerous; however, they all fall into one of five general categories. These are 1) capacity/capability problems, 2) raw materials problems, 3) problems with the way the government does business, 4) problems stemming from government regulations, and 5) economic problems (many of which are result of the other problems). The report will cover each of these general areas and its specific problems in this section. The specific possible solutions will be covered in the following section as many deal directly, or indirectly, with more than one specific problem or problem category.

Capacity/Capability Problems. The effect of capacity and/or capability on leadtimes is very straightforward; if the necessary equipment or ability to produce forgings is not available then leadtimes will lengthen. Therefore, any factor that will assure or aid in assuring that the necessary equipment and ability is available should be pursued.

Without a doubt the one problem area most often mentioned in the literature on forging leadtimes is that of capacity and/or capability. It is also the area of most disagreement and contradiction. How much actual disagreement and contradiction exists is unclear because much of it can be explained by the fact that the operational definitions for capacity and capability differ from source to source. Therefore, a definition of these terms as they will be used throughout the remainder of this study will be presented. Capacity refers to the physical ability of the in place capital equipment to produce products (18:4). Capability refers to the degree to which that physical capacity is realized (18:4). Capability is also referred to as capacity utilization.

The first area of disagreement is that of theoretical versus realistic/practical capacity. Theoretical capacity is simply the output possible if the in place capital could operate 24 hours a day. That is, three shifts per day for five days with two days for maintenance and repairs (15:6-3). Realistic, or practical, capacity is "the greatest level of output which a plant could achieve within the framework of a realistic work pattern" (15:B-10). This would normally be one to two shifts per day for a five day week. This too is an area of further confusion because from this definition, realistic/practical capacity can vary from one plant to another.

The next area of disagreement is useable versus unuseable excess capacity. Excess capacity being unused practical capacity. Useable versus unuseable excess capacity refers specifically to whether or not excess capacity is suitable to high quality, specialty metal, aerospace forging (15:6-3). F.I.A. has stood its ground in stating that the forging industry has excess capacity and capability. It contended then, and still does today, that even during the "79-80 crunch" there was excess capacity and capability in the forging industry (18:9). F.I.A. reported that in 1979, in the middle of the "crunch", only 50 percent of available aerospace forging capacity was used (17:4). It also contends that of the 50 percent that was used only one third was for military customers (17:4). However, F.I.A. is not the only one to make this type of claim in the face of long leadtimes. ASD, in Blueprint for Tomorrow, stated that in 1983 many firms were operating at less than 50 percent capacity (1:E-4). The USITC also agrees that excess capacity has and does exist. In its April 1986 Competitive Assessment of The U.S. Forging Industry the figures presented for capacity utilization from 1981 to 1984 showed, for aluminum forgings, a high of 57.3 percent in 1981 and a low of 40.2 percent in 1983, and, for titanium and high temperature alloy forgings,

a high of 67.8 percent in 1981 and a low of 50.9 percent in 1983 (Figure 4) (48:16). In addition, figures 5 and 6, constructed using USITC data, show this same information in terms of the weight of forged products shipped (48:23). On the other hand, there are the long leadtimes themselves and the fact that capacity is the most cited problem in relation to long leadtimes.

Capacity is not only the amount of capital equipment but also the age, type, and condition of that equipment. This is often said to be the worst capacity problem facing U.S. forgers. Even F.I.A. admits that the age of the capital base is "not as good as it should be" (17:6). Tom Stys, the director of marketing for Arcturus manufacturing, was quoted in a 30 December 1985 article in American Metal Market/Metal Working News, as saying "... many forgers are using the same equipment they had thirty years ago" (21:8). But the problems with capital equipment go beyond age. Today's aerospace forgings are becoming larger and larger and consist more and more of specialty metals and alloys. A great deal of the older forging equipment is simply not suitable to make these forgings. For example, there are only three U.S. forgers who can produce the very large forgings that are the backbone of today's aircraft (41:80). In 1980, Wyman-Gordon and ALCOA were the only U.S. forgers to have 50,000 ton and 35,000 ton forging presses and each company had only one of each (49:40N). The specific reason for this lack of large forging capacity is purely economic.

Capability, or capacity utilization, is an area where there is less disagreement. As previously mentioned, it is the degree to which the most is made of the existing capacity. It is largely dependent on factors such as labor and raw materials availability. The labor issue will be covered next; the raw materials issue will be discussed later.

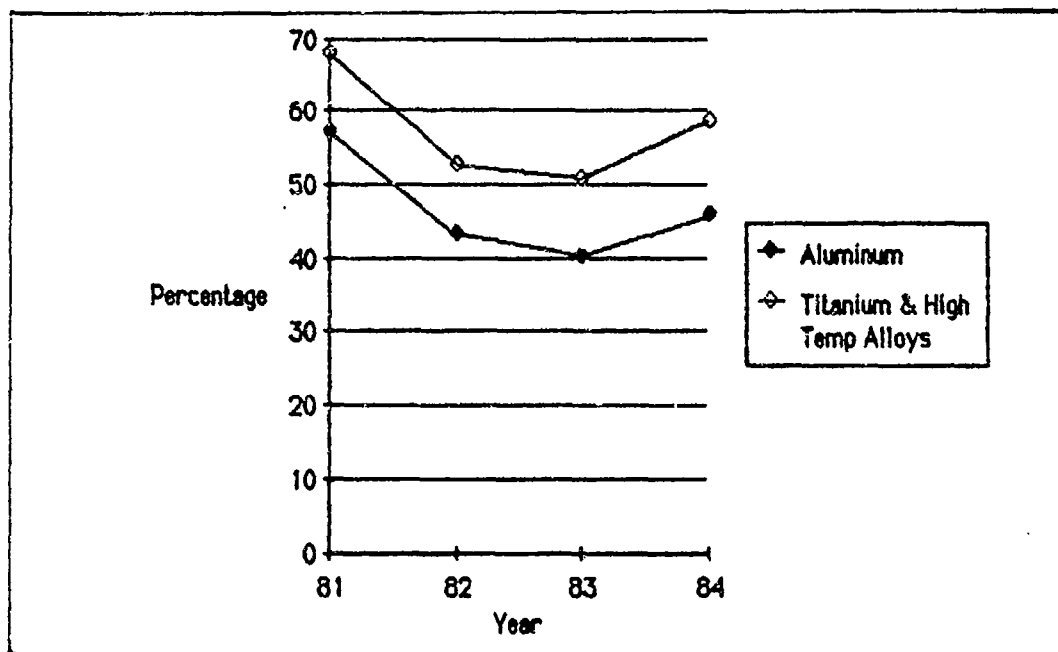


Figure 4. Capacity Utilization Rate: Aluminum, Titanium, & High Temperature Alloy Forgers
Adapted from USITC figures (48:16)

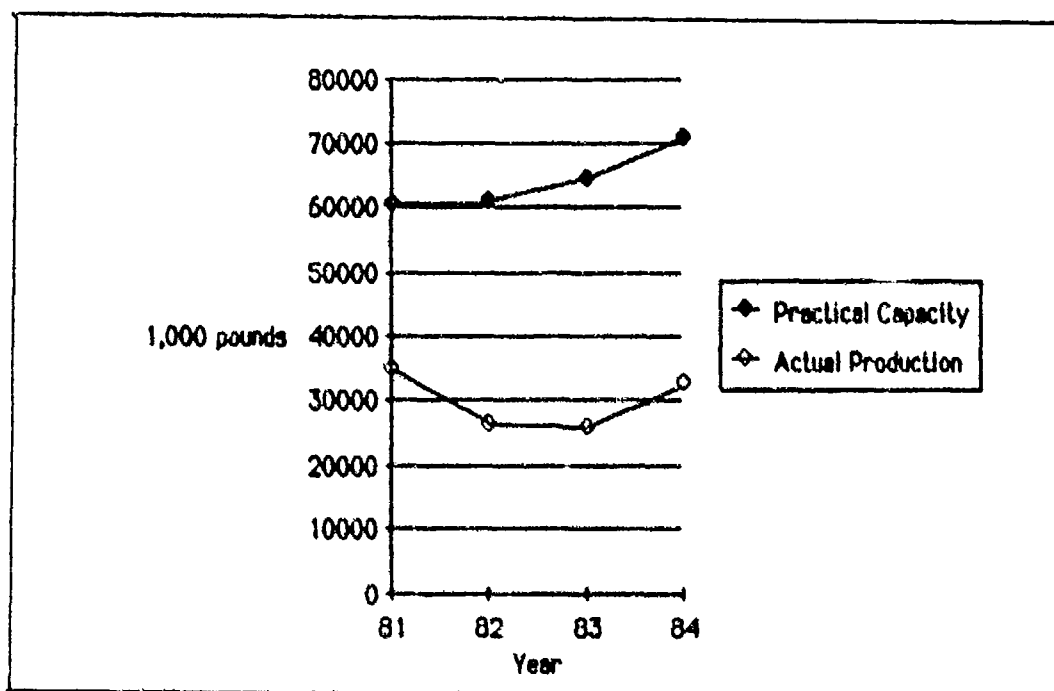


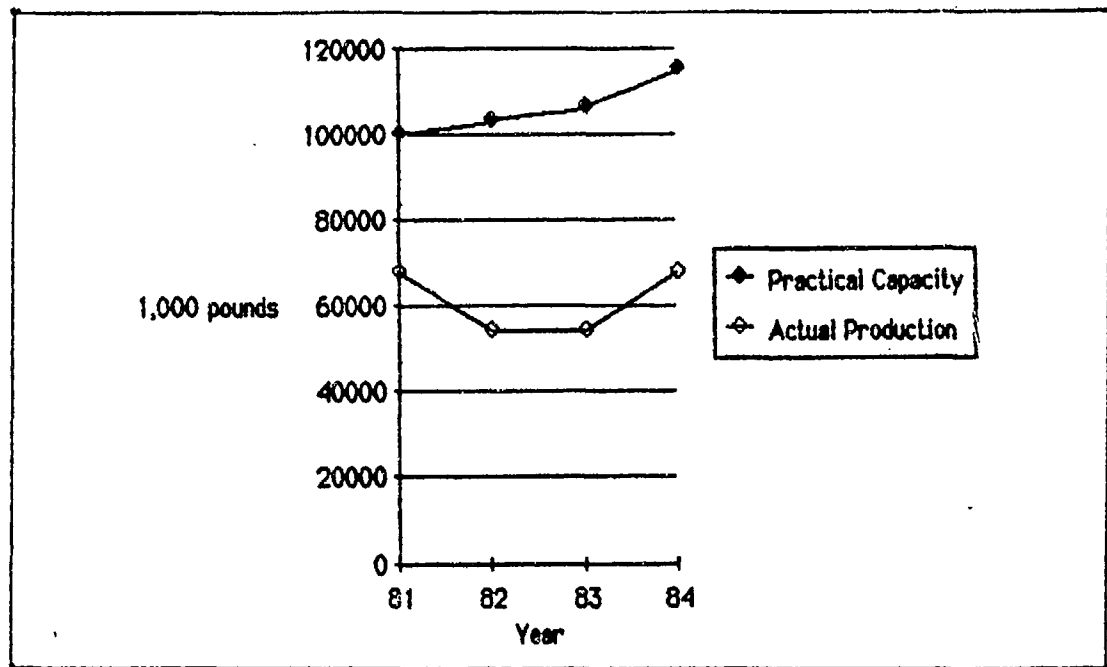
Figure 5. Practical Capacity versus Actual Production for Aluminum Forgings
Adapted from USITC figures (48:15)

Forging requires the use of highly skilled labor. It is a skill which takes

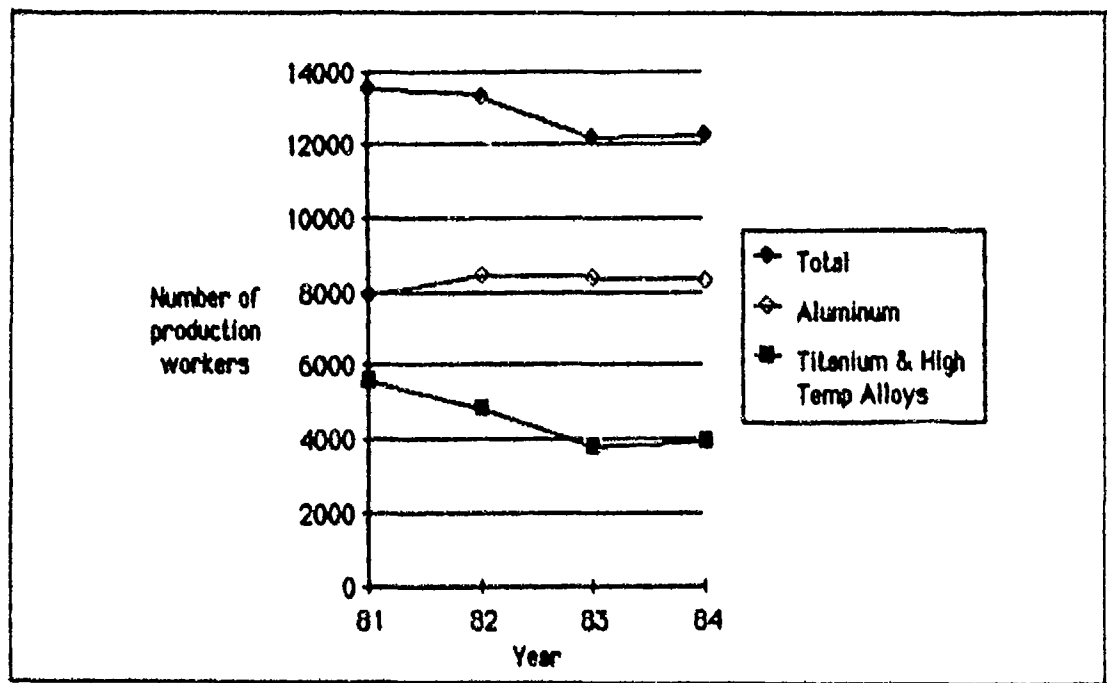
years of on the job training to develop (15:6-4). This pool of highly skilled forging labor has been steadily declining since the mid 1970's. The U.S. Bureau of Labor Statistics shows that in 1974 there were 47,300 production workers employed in the U.S. forging industry and by 1983 this number had dropped to 23,300 (3:3). This is a greater than 50 percent decrease in the production labor force in less than ten years. However, the USITC figures from 1981 to 1984 for aluminum, titanium, and high temperature alloy forgers (primary aerospace forgers) show a labor force of 13,486 in 1981 and 12,260 in 1984, a decline of only 10 percent (Figure 7) (48:18). The result of this has been that, as with any heavily unionized industry, and the forging industry is heavily unionized, the most senior employees have remained and the younger, more junior employees, have had to move to other jobs. This has left a labor force of "old-timers", many with thirty years or more of experience in the industry, and very little "new blood" (18:8). The big problem will surface when, and if, another surge comes to the industry as in the late 70's. The industry will have a great deal of trouble training the expanded labor force quickly enough.

Raw Materials Problems. The effect raw materials problems have on leadtimes is direct and can be severe. The availability of specialty raw materials such as titanium, cobalt, chromium, and aluminum were essential to aerospace forging in the late 70's and still are today. F.I.A. made the following statement in March of 1981:

Due to its light weight and high temperature properties, titanium is widely used for structural parts. Chromium and cobalt are important alloying ingredients for high temperature materials. Jet engines, for example, are highly dependent on titanium and stainless steel. A stainless steel that will withstand jet engine heat levels can't be made without chromium and cobalt as alloying ingredients (17:3).



**Figure 6. Practical Capacity versus Actual Production
for Titanium & High Temperature Alloy Forgings
Adapted from USITC figures (48:15)**



**Figure 7. Employment: Aluminum, Titanium,
& High Temperature Alloy Forgings
Adapted from USITC figures (48:18)**

The lack of raw materials was one major cause of the '79-80 crunch" as mentioned earlier.

A major reason for this was (and is) our country's near 100 percent dependence on third world countries for cobalt and chromium. In addition, nearly 100 percent of our titanium requirements are also imported (18:3).

Where do we get these raw materials? Our titanium comes almost 100 percent from Japan, Australia, the Peoples Republic of China, and the Union of Soviet Socialist Republics (18:3). Domestic sources are available, but there are environmental roadblocks to developing these sources of supply (18:3). The number of U.S. producers is very small. Production was only 24,500 tons in 1980 (15:6-9). "The U.S. gets most of its cobalt from Zaire, which cut off its exports in 1978 during internal strife largely fomented by the Soviets. Most chromium comes from Russia, Rhodesia (now Zambia), and South Africa" (41:83). South Africa has more than 95 percent of the world's chromite reserves (2:1). As with any commodity that is in short supply, the price of these metals is high. In the case of titanium the price tripled and quadrupled in 1980 during the "crunch" (15:4-16). In fact, U.S. mills processing the ore went to rationing during that time until availability increased (15:4-16).

The misuse or non use of the Defense Production Act of 1950 is another suggested problem concerning raw materials. This legislation established two systems, or programs, aimed at insuring the availability of parts and materials for defense production. These systems were the Defense Priorities System (DPS) and the Defense Materials System (DMS). The DPS was a rating system whereby certain defense contracts were rated either DO or DX. DO rated orders have priority over all commercial orders and DX rated orders

have priority over all DO rated orders and commercial orders. If necessary orders must be bumped to insure that DO and/or DX rated orders are delivered on time in accordance with their contracts. The DMS was a control measure to insure the allocation of certain basic metals to defense contracts when necessary. The specific raw materials included were steel, copper, aluminum, and nickel (15:2-1).

On August 29, 1984 the DPS and DMS were replaced by the Defense Priorities and Allocations System (DPAS) (33:V). According to Richard Meyers, DPAS Program Manager for the Department of Commerce, "DPAS is not a radical departure from DPS/DMS but rather a simplification of DPS/DMS" (31). DPAS combined the DPS and DMS, created one single regulation, removed duplication, was aimed at the business community not government agencies, and was written in simple clear language (31). Its important to note that titanium, cobalt, and chromium, the materials aerospace forgings currently depend on most, are not included. According to Business Week in May 1980 the problem was that the two systems (DPS/DMS) were neither followed by industry or enforced by the Air Force (49:40j). Joseph R. Carter, the chief executive officer of Wyman-Gordon, stated in 1980 that "the military could get all the forgings it needs, but only by displacing commercial orders" (49:40j).

Mismanagement is also charged, in regards to the U.S. stockpile of critical materials. The stockpile consists of 62 different materials and was valued at 14 billion dollars in 1980 (15:7-13). It is very difficult to get this material released. For example, in order to release material, the president's approval is required. Additionally, according to the Analysis of Critical Materials study, it must be shown that there is no other source, and economic problems do not qualify as a valid justification for release

(15:7-13). The Department of Commerce disagrees and states that only presidential approval is necessary (31). There is concern that some of the material may become unfit for use. The reason is that new alloys and technologies may make some of the material obsolete before it can be used (17:3).

Problems With the Way the Government Does Business. This problem area includes annual funding of DOD programs, stringent military specifications, high quality control requirements, and stringent supplier qualification requirements. The effect on forging leadtimes caused by problems in this area is indirect, but concerns both capacity and capability. The effect is quite often to limit the number of forgers willing, or able, to produce aerospace forgings and make it too risky economically to invest in new expanded capacity.

The most frequently cited of these problems is the government practice of funding DOD programs on a year to year basis. This practice, while it does give Congress a great deal of control, is completely alien to the way in which the forging industry, and the commercial market in general, functions. Any civilian firm, but especially a forging firm, needs to plan ahead, carefully, and as far in advance as possible. The cost of new capital equipment in the forging industry is very high, skilled labor is expensive and new personnel take from six months to a year to train. Forgers simply cannot, and have shown that they will not, make these types of investments based on undependable single year contracts. In order to make capital expansions, they need a more stable market for their products. Figure 8, constructed from information contained in the USITC Competitive Assessment of The U.S. Forging Industry, shows the substantial reduction in capital expenditures which has occurred since 1981 (48:21). Too many forging firms have made

substantial capital investments only to be economically stranded by the DOD. They will not make the same mistake again, or for the first time, based on DOD's track record. Business Week made the following assessment in February of 1980:

In part, the industrial bottleneck is the result of on-again, off-again defense budgets. Thousands of suppliers dropped out of the defense business during the funding slump of the early 70's, and others have been reluctant to gear up because they fear another bust (41:81).

F.I.A.'s view is that "Stop and go production can't be survived by forgers. Effective capability can't be maintained " (18:6). Single year funding just does not allow the forger any stability. He cannot risk purchasing newer, up to date equipment, so DOD orders are produced on thirty year old machinery. He cannot risk a larger labor force, so DOD pays for overtime for the existing labor force. He cannot risk large, economic purchases of raw materials, so DOD pays for the smaller uneconomic lots of raw material. Single year funding hampers the forger because he cannot plan ahead or risk expanding; it hurts the economy because jobs and capital goods purchases are not realized; and it hurts the taxpayer because they are paying more than necessary for DOD systems.

Overspecification, high quality control standards and stringent supplier qualification requirements are also frequently mentioned problems. The argument is that Air Force specifications are higher than for comparable commercial systems (15:4-8, 4-9). Sometimes the higher specifications are necessary, but often they are simply "gold plating". They are implemented out of habit without considering the affect they will have. The result is that product cost goes up; the quantity ordered goes down; and the additional

time required to insure the specification is met adds directly to leadtime. Forgers may need to purchase more specialized or tighter toleranced test and production equipment and this makes the DOD order much less desirable for the forger. DOD quality control levels are also higher than for commercial orders (15:4-10). This requires additional time and resources, which increase costs and add directly to leadtime. Lastly, DOD supplier qualification requirements are demanding, expensive, and time consuming for the forger, especially smaller firms (15:4-8). The net effect of these requirements quite often backfires and causes limited if not sole sources of supply for some forgings (15:4-8).

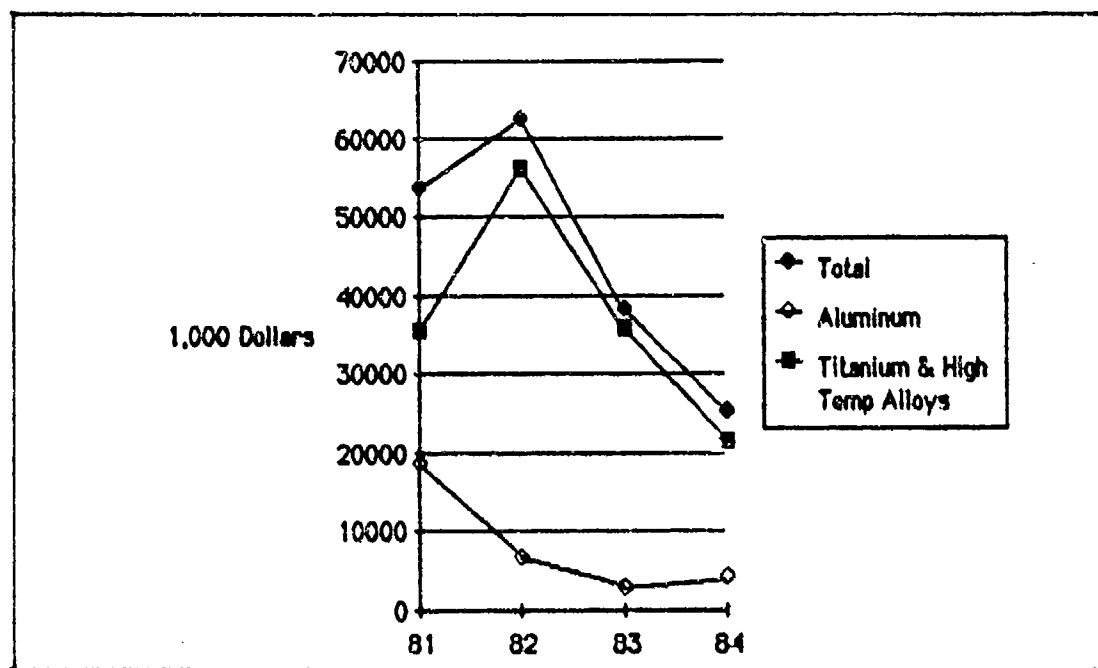


Figure 8. Capital Expenditures: Aluminum, Titanium, & High Temperature Alloy Forgers
Adapted from USITC figures (48:21)

Problems Caused by Government Regulations. The effect of government regulations problems on forging leadtimes is indirect, but falls into the capacity, capability, and raw material areas. Government regulation

problems can be summed up in two words, OSHA and EPA. During the last decade OSHA and EPA have implemented a myriad of regulations which have severely impacted and hampered the forging industry. The fact is, that:

Since 1979, 76 forging plants out of some 400 have closed down, their work forces (estimated to be 10,000 people) have been forced to seek other types of employment, and the knowledge and skills of their organizations have been lost to the nation (16:1).

Appendix 1 lists these firms, when they went out of business, and the number of jobs lost with each one. While no figures exist to say how many of these firms were driven out of business principally or in total by OSHA and/or EPA, some believe that OSHA and EPA have been a major contributing factor in many closures. This has been much worse on small forgers because they cannot afford to absorb the costs of the modifications and changes as well as larger firms (15:5-15). The effect of OSHA and EPA goes further. These agencies have made it more difficult to expand capacity through the purchasing of new capital equipment. Forging hammers, while not as versatile as forging presses, are much less expensive (49:40N). For many forgers the purchase of an additional press is simply beyond their fiscal abilities, whereas a new hammer might not be. However, recent noise regulations are making it all but impossible to purchase new hammers because they cannot meet noise level requirements (49:40N). And finally, as mentioned earlier, EPA regulations are slowing down or prohibiting the economically feasible utilization of some domestic titanium resources.

Economic Problems. Economic problems include the issue of imports, some DOD policies which result in suboptimization, and carry overs from

other problem areas. It is essentially a catch all in that the end result of some other problems can best be explained economically. As far as impacting leadtimes, the affect is indirect and pertains to both capacity and capability.

Imports are a problem, the dimensions of which are not totally known, due to the lack of necessary data. The reason is that import statistics do not differentiate to a great enough degree the products coming into the U.S., and therefore, an accurate accounting of imported forgings cannot be accomplished. For example, raw forgings coming into the country as the product forgings are accounted for, however, the forgings in other finished products such as automobiles or subsystems for products assembled in the U.S. are not accounted for accurately.

Imports tend to be directed towards the high production/continuing products markets which are the profit base of U.S. forgers (18:6). These imports are quite often subsidized by their governments, according to F.I.A., in order to maintain their U.S. market share and to ensure stable employment at home (3:10;11). The U.S. government does not subsidize forgers to maintain stable employment and therefore some forger's markets are being significantly impacted by imports. For example, Caterpillar corporation has been purchasing imported forgings for as much as 70 percent less than a comparable U.S. produced forging (25:6). Caterpillar contends that the price differential is a result of greater efficiency, larger plants and production runs, and newer technology; F.I.A. strongly disagrees (25:6).

The big danger from imports is not that the large DOD forgers will be hurt but rather the smaller firms. If imports eventually drive many smaller forgers out of business then that capacity will be lost and some dependence

on overseas forgers may develop. If increased demand in Europe or the Orient should occur then there is a risk that those overseas producers may leave U.S. customers stranded in order to fulfill that demand (18:7). When those U.S. customers then turn to U.S. forgers to supply them, the necessary capacity or capability may not be there. This type of scenario could very well create a demand situation for forgings that would rival or surpass the "79-80 crunch".

DOD has, and does, engage in policies and practices which are clearly suboptimizing. The use of GOCOs, government owned and contractor operated plants, and single year funding are the most common examples. These practices create economic conditions which discourage forgers from expanding capacity and implementing newer technology through the purchase of new capital assets.

First, lets look at government owned and contractor operated plants or equipment. Until recently, the DOD owned a great deal of the forging capacity in the U.S. For example, in 1980, 80 percent of the closed die hydraulic presses over 20,000 tons, 60 percent of the extrusion presses over 7,000 tons, and 30 percent of the forging hammers over 35,000 pounds were owned by the DOD (15:B-13). DOD, by giving, loaning, or renting this equipment (which many non-forgers consider quite old) to forgers, discourages new capital investment. Obviously, the return on investment when no investment is made is higher than when one is made. Even though the government owned equipment is less efficient, the forger will still make a comparable or greater profit, and he does so without the risk of possibly being stuck with an unproductive resource should business drop off. An illustration of just how devastating a situation like this could be to a forger was presented by Joseph R. Carter, Wyman-Gordon's chief executive officer,

in May of 1980. Carter estimated the cost of a new 50,000 ton press to be about 200 million dollars in 1980. This, according to Carter, would be equal to the total net worth of Wyman-Gordon, which is the nation's largest aerospace forger (49:40N). If given the option of using government owned plants or equipment, antiquated or not, few firms would choose to risk their financial well being to obtain new capital assets when the market return on that investment is so uncertain.

Single year funding has an almost identical affect. The argument here is that forgers cannot make any capital expansions, labor force increases, or purchase raw materials in economic order quantities, based on a one year DOD commitment. Therefore, they do not. They do not buy new equipment; they do not hire new labor; and they do not order materials economically. A contract may in fact run for many years, but without a guarantee of more than one year the forger must risk as little as possible.

The last problem of an economic nature facing DOD, regarding forgings, is the forging industry's near total non-dependence on DOD business. While this is a problem for DOD it is a plus for the forging industry. As mentioned in the first section of this literature review, the number of forgers doing aerospace business is small, about 40 firms. According to the Analysis of Critical Parts and Materials study, of these 40, none are more than 50 percent dependent on DOD business (15:6-2). Past experience with DOD cutting funding and leaving firms stranded economically has made the forging industry very protective of its non-dependence on DOD. The majority of forging industry business is commercial, and therefore, drives and determines what the industry as a whole does, not DOD (1:5-122). Not only do DOD orders not direct the forging industry, they often take a back seat to commercial orders:

The commercial orders involve longer production runs, standardized parts, and greater profitability for the contractors. There is, therefore, every incentive for the contractor to fulfill commercial orders before the special defense orders (15:4-10).

This concludes the discussion of probable causes and problems responsible for excessive forging leadtimes found in the available literature.

Proposed Solutions to Leadtime Problems

Numerous possible solutions to excessive forging leadtime problems have been suggested. Those most often cited are as follows:

- 1) Implement multi-year funding as opposed to single year funding.
- 2) Create economic incentives to encourage and increase new capital investment.
- 3) To the greatest extent possible, cease to create new, and eliminate existing, suboptimizing policies, practices, and programs such as GOCO's.
- 4) Stabilize the volatile raw materials supply by making better use of the existing programs and assets already available. (ie. DPS/DMS and stockpile)
- 5) Implement policies and incentives to increase the use of new, more efficient and productive forging technologies.

Multi-year Funding. First and foremost among the possible solutions is the implementation of more multi-year funding. This is not only the most cited solution but essentially a consensus among both DOD and industry representatives. It is nearly, or reportably has the potential of being, a complete solution in and of itself due to the large number of problem areas it impacts. F.I.A. has this to say concerning multiyear:

Knowing military requirements in advance, forgers would be able to plan capital expenditures for equipment, invest in a highly skilled labor force, and insure that needed material was on hand (17:7).

Business Week stated that "of high importance would be multi-year procurement budgeting so that contractors could plan intelligently their own capital and manpower investments" (41:84). Multi-year funding will result in more stable business for forgers, economic production runs, larger, more economic orders of raw materials, increased capital investments, and a larger labor force. The reason being that forgers will be assured of steady flows of business for long enough periods of time to recapture the cost of new capital and labor (15:7-8). Another possible version of multi-year funding would be multi-year funding for specific components and products rather than an entire program (1:7-12). In this way, program stability for forgers, and shorter leadtimes would be achieved without as large a commitment of funds as would be required for multi-year funding of an entire system or program. Finally, of the five major problem areas addressed in this study, four would be favorably affected by the implementation of this one solution. The only area multi-year funding will not be able to favorably impact is the OSHA and EPA concerns.

Economic Incentives to Increase Capital Investment. This solution area to reduce leadtimes boils down to direct and indirect monetary injections into individual forging firms. They include such things as investment tax credits and higher depreciation allowances on capital investments for equipment used to produce DOD orders (15:7-14). It also includes more flexible profit margins so that DOD orders could compete more favorably with commercial orders (15:7-7). Government loans, loan guarantees, and commitments to purchase, which would be used for and encourage, new capacity expansion are included (15:7-14). Next, (although it contradicts other solutions) use of a Plant Equipment Package (PEP) when there is no other way to get the needed capacity. PEP is simply furnishing

either an entire plant, production line, or piece of equipment to a forger in order for him to be able to produce a particular product (15:7-14).

So far, the economic solutions identified have all been indirect injections of capital to suppliers. Two direct injections are initial provisioning (the buying of "up front" spares) and advance payments for orders (15:6-7;7-8). The net effect of all these economic solutions, if successful, will be to strengthen contractors financially and thereby encourage increased investment in new capacity and capability. This increased capacity and capability should then reduce forging leadtimes, or at least offer a buffer so that the next "crunch" will have a less severe impact.

Cease Suboptimizing Policies and Practices. This alludes to the need for multi-year funding, as previously discussed, but more specifically, to the need for elimination and removal of as much of the GOCO plants and equipment as possible. ASD in Blueprint for Tomorrow had this to say, "... government furnished plant equipment is of virtually no use in fostering productivity growth" (1:6-12). ASD went on to say that "The long term productivity needs of the industrial base will be better served through private sector capital investment" (1:7-13). The belief is that by removing this crutch, forgers will increase investment in new capacity, which in turn will reduce leadtimes.

Stabilize Raw Materials Supply. Three suggested corrective actions cited in this area are incentivizing new raw material capacity, rotation of and making the national stockpile easier to use, and making better use of the Defense Priorities and Allocations system (DPAS) (17:3;15:7-10). Title III of the Defense Production Act of 1950 could be used to provide loans and loan guarantees for new, domestic raw material exploration or to develop technology that would allow some existing reserves, held up by ecological

concerns, to be utilized (15:7-10).

Next, as mentioned before, there is concern that the material in the national stockpile may cease to be fit for use. F.I.A. believes that the stockpile should be regularly rotated to insure that the material is and will remain up to industry standards (17:3). Also, it is desired to make the stockpile easier to use, more accessible in times like the "79-80 crunch". If the stockpile could have been used as a buffer then, the "crunch" might not have had as severe an impact.

Finally, making better use of the DPAS could alleviate much of the raw material problem. First, the current most critical raw materials, titanium, cobalt, and chromium are not included in the DPAS. Some believe the DPAS needs to be brought up to date to include these materials. However, the greatest room for improvement is believed to simply be better implementation of the current programs. F.I.A. stated, in December 1981, that (the then) DPS/DMS cannot work unless the Department of Commerce employs it (18:6). Supposedly contractors do not implement it and it is not enforced by the Air Force. The belief, in regards to DPAS, is that it would have a significant impact on reducing materials shortages and, therefore, leadtimes if seriously employed when necessary.

Technology Improvements. This possible solution to forging leadtimes involves incentivizing the use of new more efficient and productive forging technologies. Specifically, near net shape forging processes and Computer Aided Design (CAD) and Computer Assisted Manufacturing (CAM).

The new near net shape forging processes include hot die forging, isothermal forging, and hot isostatic pressing (49:40N). In hot die forging the dies are heated so that there is less heat differential between the die and

workpiece and subsequently less heat loss and cooling of the workpiece during forging. Isothermal is an extension of hot die forging in that the dies are heated to the same temperature as the workpiece. In isothermal there is no differential between the dies and workpiece. Finally, hot isostatic pressing is the compression of powdered metal into a desired shape. The metal powder is poured into a stainless steel can, or mold of the desired part. Pressure is exerted on the can from all sides at once and the powder solidifies into the desired shape (38). These processes have two distinctive advantages over other forging technologies. First, they create less scrap, less wasted material during the forging process (49:40N). Wyman-Gordon began using some of these technologies in the late 70's and confirms the fact that raw material usage may be reduced by as much as 75 percent in some cases (49:40N). This alone has the potential to end the raw materials problems that face the forging industry. The other advantage of near net shape processes is that much less post forging finishing work is required. The amount of machining required to finish a near net shape forging is minimal compared with other technologies. This may save both time and labor which could mean higher profits for forgers and improved leadtimes for customers.

The other major type of new technology is Computer Aided Design and Computer Assisted Manufacturing or CAD/CAM. CAD/CAM can reduce the amount of labor required and help to reduce actual production time (1:2-18). CAD has been especially successful in die design where it greatly reduces the cost of, and time required for, this phase of the forging process. Dies have to be reworked less because they tend to be correct, or much closer to correct, the first time. CAM reduces the need for expensive skilled labor and can operate some types of forging machinery more quickly than a

human operator. The overall effect of these technologies, if heavily implemented, will be significant dollar and time savings which will in turn reduce leadtimes.

Summary

To summarize what has been covered in the literature concerning forging leadtimes it is necessary to first restate that DOD aerospace forgers are atypical of the normal industry firm. They are a small concentration of the largest firms. Industry firms are sensitive to the business cycle and have been through extreme swings of the business cycle in the past, at the hands of both general economic conditions and DOD. The worst leadtime conditions existed in the late 70's and early 80's and are what initially focused attention on the problem. Leadtimes skyrocketed from less than one year to as many as three during this period. The reasons vary, but, according to the available literature, include dependence on foreign sources of, and lack of domestic sources of, raw materials; aging capital equipment and technology which is often not suitable for aerospace forging production; single year funding and other peculiarities of doing business with the U.S. government; and various OSHA and EPA regulations which have hampered or driven many firms out of business. Proposed solutions include implementing longer term, more stable, DOD buying patterns; stabilizing raw material supplies as best as is possible; and expanding both the capacity and capability of the industry by increasing industry investment in new capital equipment, technology, and labor.

III. Methodology

Chapter Overview

This chapter describes the method in which data was collected to accomplish the objectives of the study, as outlined in Chapter 1. Specifically, it covers the method used to collect data, the instrument used, the population, how the data was analyzed, and the resulting limitations or biases.

Method Used to Collect Data

Personal interviews were used to collect data because, due to the subjective nature of the type of information being sought, the quality of interview information is superior to other types of information. The advantage to using personal interviews, as opposed to a survey or other method, is that the information obtained is in much greater depth and detail. Interviewees were not limited to predetermined responses. They were able to explain their responses. The interviewer was able to not only get the interviewee's response but the reason behind that response. C. William Emory, in his text Business Research Methods, supported this view concerning interview information and stated that "The greatest value lies in the depth and detail of information that can be secured. It far exceeds the information secured from telephone and mail surveys." (13:160).

Instrument Used

A structured interview guideline was developed from information obtained during the review of literature. The interview guideline contained

a general statement about the study and the objective the interviewer was trying to accomplish. It also contained 45 questions and/or areas for discussion. These consisted of 16 questions concerning the interviewee's firm and two lists, one of probable causes or problems responsible for long leadtimes and the other of suggested solutions or "fixes" for long leadtimes. Each interviewee was sent a copy of the guideline in advance so they would be prepared to address each question or issue. A copy of the interview guideline is contained in appendix 2.

Selection of Interviewees

It was stated in the Scope and Limitations section of Chapter I that the study was directed toward that portion of the forging industry which has the longest leadtimes, and therefore, the largest impact on total system leadtimes, specifically, forgings of large physical size and those made of specialty metals and super-alloys. Four such firms were visited and interviewed. These firms were ALCOA Forgings Division (Cleveland, Ohio), Kropp Forge Company (Chicago, Illinois), Ladish Company (Milwaukee, Wisconsin), and Wyman-Gordon Company (Worcester, Massachusetts). Three of these four, ALCOA, Ladish, and Wyman-Gordon are considered to be among the four largest aerospace forgers in the United States. Most of the other large aerospace forgers are located on the west coast, with the exception of Cameron Iron Works (Houston, Texas).

In addition, and as a supplement, to the forging firms, interviews were conducted with individuals or firms that had expertise in specific problem or solution areas. These included RMI Company (Niles, Ohio), three members of the Department of Commerce's Office of Industrial Resource Administration, two DOD civilians and two active duty military officers at Wright-Patterson

AFB, and one forging industry trade association official. A complete listing of all interviewees (forgers and non-forgers) and their areas of expertise is contained in appendix 3.

Data Collection

Eleven interviews were conducted involving 20 people between 13 January 1986 and 4 August 1986. The interviews were generally conducted with one individual who was either able to respond to all questions or had solicited responses ahead of time from other individuals within their firm. However, in one instance there were two interviewees present and in another a panel of four individuals was available to respond to the interview guideline.

The time required for each interview varied from as little as 20 minutes to as much as three hours. The time for the four forgers was generally longer because they were questioned on all areas, whereas the non-forgers were only questioned on their area of expertise.

All interviews were taped, with the permission of the interviewee, in order to make transcription possible, insure that quotations were accurate, and to insure note was taken of any responses missed or overlooked at the time of interview. The four interviews with the forgers and the interview with RMI Company, a titanium mill, were transcribed and resulted in 281 pages of text.

During the interviews some individuals chose to speak off the record on certain topics and asked not to have those responses attributed to their firms or organizations. Also, proprietary information was provided while conducting the interviews in order to give a better understanding of the topics or issues, but with the understanding that it would not be included in

the report. Obviously, all such requests were honored in compiling this report. In fact, copies of the applicable portions of the report were sent to the interviewed forging companies and the interviewed raw materials processor for their editing. This served to both insure the technical accuracy of those portions of the report and to insure all statements and ideas attributed to the companies met with their approval. Therefore, throughout the remainder of the report certain statements are prefaced with phrases such as "one forger stated" or "one individual said", etc. with no specific reference.

Data Analysis

Analysis of the data consisted of consolidating the responses to each interview question or discussion area. No attempt was made at statistical analysis. The objective was to get a general understanding of how forging firms actually view the problems and possible solutions affecting leadtimes. The responses were consolidated and any consensus or trend in the responses was evaluated. But just as important as the consensus, or trend, itself was the reasoning behind it. Therefore, both the consensus, or trends, and the reasons behind them are reported in the analysis section.

Limitations and Biases

There are several limitations, or biases, dealing with both the population and the way in which data was collected and analyzed that need to be mentioned. First, no statistical analysis was possible due to the small sample size (4 forging firms) and the nature of the interview responses. Many of the responses could not be categorized into discrete responses that could then be measured statistically without ignoring much of the

explanation behind the responses. Second, and the most obvious bias, is the fact that the interviews were only with forgers. Others were interviewed, but only for supplemental information on specific problems or solutions. The responses are probably somewhat different than what would have been received from end users of forgings such as prime contractors and DOD personnel. This was not considered a significant problem, however, because the objective was simply to get a better understanding of problems and solutions effecting leadtimes. It was determined that forgers, who are closest to the problems and solutions because they live with them on a daily basis, would have as much, if not more, insight into the problems and solutions as anyone.

IV. Analysis and Discussion of Interview Responses

Chapter Overview

This chapter contains the consolidated responses of the four forging firms to the interview guideline, and their reasoning for those responses. It also contains, where applicable, supplemental information received from the non-forging firm interviews. The responses to the interview guideline are divided into three sections: general questions about the firms, probable causes or problems responsible for long leadtimes, and possible solutions, or "fixes", for long leadtimes.

General Questions About the Firms

How Many Employees Does Your Firm Have? This question was asked in order to both determine the size of the firms actually doing DOD aerospace business, and also to get an idea of the affect of recent economic conditions on their labor forces. All four forging firms interviewed gave the interviewer employment figures for both the boom period of 1979-81 and 1986. Ladish reported employment of approximately 5,400 in 1979-81 and a reduction to approximately 2,150 in 1986 (35). Kropp Forge reported employment of 650 in 1979-81 and only 350 in 1986 (27). ALCOA reported employment to have been approximately 1,800 in 1979-81 and a reduction of approximately 400 to 1,386 in 1986 (10). And finally, Wyman-Gordon reported 1979-81 and 1986 employment to be essentially the same at approximately 2,025 (38). These figures amount to a 60.18 percent decrease in employment for Ladish, a 46.15 percent decrease for Kropp, and a 22 percent decrease for ALCOA.

The mixed responses of these forgers neither support or refute the U.S. Bureau of Labor Statistics figures that reported a greater than 50 percent reduction in employment, or the April 1986 USITC report which reported only a 10 percent reduction in employment for the aluminum, titanium, and high temperature alloy segments of the forgings industry (Chapter II, p. 17-18).

Of These Employees, How Many Are Direct Labor and How Many Are Indirect Labor Employees? This question was asked as an extension of the initial question concerning the total number of employees. The purpose was to determine if the percentage change in employment was different for production (direct labor) and non-production (indirect labor) employees. Unfortunately, the responses received from the forgers were inadequate for any determination to be made. Some forgers interviewed did break their responses out into direct and indirect labor. However, each firm defined production versus non-production or direct versus indirect slightly differently. Therefore, the information received was not usable.

What Is the Dollar Value of Your Annual Sales? This question was asked for essentially the same reasons as the initial employment question. First, it was to get a feel for the size of the firms doing DOD aerospace business and also to determine the affect of recent economic conditions on sales. Responses were varied and went from no response to full disclosure of annual sales both during the 1979-81 period and for 1985. ALCOA chose not to respond to this question based on the fact that it was proprietary information. Ladish also chose not to report specific figures based on the proprietary nature of this information. Their current annual sales appear to be in excess of 300 million. Wyman-Gordon only responded during the interview by reporting that annual sales were in excess of 350 million in

1985 (38). However, Wyman-Gordon provided its annual reports for 1982 through 1985, and these reports stated annual sales to have been 610 million in 1981 and down to 384 million in 1985 (50:2; 53:2). Kropp forge was the most open with this information and reported 1979-81 sales to have been approximately 56 million and down to approximately 33 million for 1985 (27). These sales figures amounted to a 37 percent decrease for Wyman-Gordon and a 41 percent decrease for Kropp.

The information received from the forgers either directly, or indirectly from their annual reports, strongly supports the figures reported by both the F.I.A. in January, 1986 and the USITC in April, 1986 (Chapter II, p. 7).

Of These Sales, What Is the Ratio of Commercial to DOD Items? This question was asked in order to determine the actual dependence of firms doing DOD aerospace business on DOD business. All forgers interviewed responded fully to this question. ALCOA reported that 40 to 50 percent of their business was ultimately for DOD use (10). Wyman-Gordon reported that, currently, approximately 65 percent of their business is for DOD use (38). And, Ladish reported that approximately 50 percent of their current business is for DOD use (35). Finally, Kropp reported that DOD's share of their business is approximately 60 percent (27).

The responses of the forgers interviewed strongly disagree with information contained in the literature review that suggests the level of dependence to be less than 50 percent for all forgers (Chapter II, p. 28).

If Possible, What Is Your Firm's Profit Margin? This question was asked in order to determine what the profit margins for these firms were and if they had experienced a decline in these margins since 1979-81, as suggested in the literature review (Chapter II, p. 7). Only one firm responded to this question and that response was that the firm "had

operated at a loss for the past three years" (1983-1985). This, clearly, implies a decline from 1979-81 levels, however, to what degree is still uncertain as the 1979-81 margins were not volunteered. The other three forgers all declined to respond to this question as it was proprietary information. Therefore, little or no information was obtained from this question so far as responding to whether profit margins have generally declined and to what degree.

Is There A Difference In The Profit Margin For Commercial Versus DOD Items, And If So What Are The Margins? This question was asked to determine if, as alluded to in the review of literature, the profit margins on commercial orders are sometimes higher than for equivalent DOD orders. The belief being that this will make commercial orders more attractive to forgers than DOD orders and thereby increase the chances of those orders being produced over DOD orders when resources are scarce (Chapter II, p. 30). There was a consensus among all four forgers in responding to this question. They all reported that there is no difference between the profit margin for a DOD item and a commercial item; all orders are commercial orders (38; 10; 27, 35). The explanation given is that forgers are not prime contractors, they are sub-contractors producing items for the prime or other sub-contractors who, in-turn, produce items for the prime. Firms purchasing forgings, whether prime contractor, sub-contractor, or commercial airline, compete the various aerospace forging firms against each other. Therefore, every order is a commercial order. In fact, forgers often do not know initially whether the item is for eventual use by DOD or a commercial customer (38; 10; 27; 35).

What Is The Average Age Of Your Various Categories Of Capital Equipment (Metal Cutting, Presses, Hammers, Heat Treatment, etc.)? This

question was asked to determine if the equipment in use today is as antiquated as alleged in the literature review (Chapter II, p. 16). All four forgers responded to this question in a very similar manner. ALCOA reported that their worst case was some of its presses which were initially installed 30 to 40 years ago. However, all these pieces of equipment have been rebuilt and now are technologically current (10). Wyman-Gordon reported that all their older equipment has been rebuilt and that you can not simply look at initial purchase year as a measure of the age and ability of forging equipment (38). Ladish reported that all their older equipment has also been rebuilt. They also pointed out that the newer technology equipment, such as isothermal equipment, is no older than ten years and in many cases only a couple of years old (35). Kropp forge reported that some of their equipment had been initially installed as early as the 1920's and 1930's, but no original parts remained on that equipment. It has all been completely rebuilt (27). The general points brought out by the forgers are first, that all the older equipment has been rebuilt. When it is rebuilt it usually comes back into service more capable than it was when new. The equipment comes back with capabilities or features it did not have initially, such as numerical or computer control. Second, over time, nearly every single piece of a machine may be replaced so that it is essentially a new piece of equipment. And finally, all of the newer near net shape technology equipment, such as isothermal forging equipment and hot isostatic pressing equipment is only a few years old.

What Would It Cost You To Either Replace This Equipment Or Add New Capacity? This question was asked to determine if some of the estimates of adding new capacity brought out in the literature review are valid: 200 million for a new 50,000 ton press (Chapter II, p. 27-28). Only one firm

attempted to actually answer this question and it reported that it thinks it could replace its entire operation for 300 to 500 million. This would include both a 35,000 and 50,000 ton press. Two others gave no answer because they simply could not come up with a valid estimate. And finally, one forger responded by reporting it would cost "more money than we have". The one forger who responded to this question contradicted the high figures from the literature review, however, one response is not enough information to make an assessment. Therefore, the information received from this question is insufficient to draw any conclusion about the current cost of replacement or new capacity.

At What Level Of Capacity Have You Operated And At What Level Are You Operating Today (Number Of Shifts, Utilization Rate)? This question was asked in order to determine what current utilization rates are at the interviewed forgers, and if the actual utilization rates during the 1979-81 period were as low as those suggested in the literature review (Chapter II, p. 15-16). All of the firms responded to this question concerning the utilization rates. The number of shifts portion turned out to be hard to answer because shifts differ between departments and types of machinery within any given forge shop. Therefore, the shift information received was insufficient to make any assessments.

ALCOA reported that during the 1979-81 time period it operated at as much as 62 percent of practical capacity, and in 1985 it operated at approximately 40 percent (10). Wyman-Cordon reported that it has operated at as much as 75 percent of practical capacity, but in 1986 is operating at approximately 50 percent (38). Ladish reported that it operated as high as 80-85 percent of practical capacity during the 1979-81 time period, but in 1986 is at approximately 45 percent (35). And Kropp

reported that its 1986 utilization rate is approximately 45 percent (27). These utilization figures tend to disagree with the F.I.A. figures, from Chapter II, for the 1979-81 time period, in that they are generally higher than the 50 percent claimed by F.I.A. for that period. They tend to agree more with the USITC figures, from Chapter II, that show 1980-81 utilization rates to be approximately 58 percent for aluminum forgings and approximately 68 percent for titanium and high temperature alloy forgings. However, the more current, 1984, USITC figures suggest utilization rates of approximately 59 percent for titanium and high temperature alloy forgings and approximately 45 percent for aluminum forgings. None of the forgers reported current (1986) utilization rates in excess of 50 percent. Therefore, the forgers responses disagree with the 1984 USITC figures for titanium and high temperature alloy forgings utilization rates.

One factor causing confusion is that most of the forgers produce aluminum, titanium, and high temperature alloy forgings. Some produce much more of one type than another and trying to determine how the total utilization rate was divided between aluminum, titanium, and high temperature alloys was not possible from the information obtained.

It is clear from the responses that for some forgers large amounts of excess capacity did exist in the 1979-81 period, and large amounts of excess capacity do exist today (1986) at every forger interviewed.

At What Level Could You Realistically Operate At If Necessary (3X8X5, 2X10X5, etc.)? This question was asked in order to determine what type of surge capability the forgers actually think they could generate. Unfortunately, and probably due to interviewer error, the responses to this question were almost totally in shifts as opposed to the responses to the previous question which were primarily in utilization percentages.

Therefore, comparisons between the two questions would be very difficult.

ALCOA reported that it is currently operating on a five day week with occasional weekend work when required to meet customer demand. It is running three shifts but not all equipment runs all three shifts. If necessary, ALCOA has determined it could man up for a full three shift, five day operation. Two days each week would be required for maintenance and repair. While it could not maintain a full three shift operation seven days a week, certain auxillary operations, such as heat treatment, could operate continuously (10). Wyman-Gordon reported that 80 percent of practical capacity would be a maximum. Its several plants have varying operations schedules, but it thinks two shifts six days a week (2X8X6) would be a realistic estimate (38). Ladish also reported that two shifts six days a week would be a reasonable estimate. However, some operations, such as heat treating, would be capable of continuous operation (3X8X7) (35). Kropp reported that it would depend on each particular department. Some could only operate one shift, some two shifts, and some three shifts (27).

While the responses above are somewhat vague, the reasons and explanations behind them are not. Furthermore, every single forger interviewed brought out essentially the same reasons and explanations for their responses. First, no single answer applies to an entire forge plant. Every plant is a collection of smaller shops and operations each of which have its own abilities and limitations. Some such as heat treating can operate continuously. However, some, such as Wyman-Gordon or Ladish's hammers, normally only operate during limited hours due to noise (Cudahy, WI) or nuisance (Worcester, MA) ordinances. Wyman-Gordon added that if a surge or national emergency required it it could and would go to more than one shift at its Worcester, Massachusetts plant (38). Second, no forge plant

can operate all departments on a continuous basis (3X8X7). The reason is that much of the forging equipment requires regular and frequent maintenance. This is usually accomplished on the two days, Friday-Saturday or Saturday-Sunday, the forge plant is not operating each week. Continuous operation does not allow for proper maintenance and may ultimately lead to more serious maintenance problems which will, in-turn, cause even greater delays. Finally, aerospace forgers are job shops. The different products produced are numerous and usually production runs are small, 50 to 75 pieces on average. Almost every product requires a different set of operations to produce it. Therefore, it is nearly impossible to schedule the plant operation as efficiently as a forger who mass produces a small number of products (38; 10; 27; 35). Bob DeLay, ALCOA's forging division marketing manager, made the following statement concerning small production runs as opposed to mass production:

In the C5-A program we make sixteen forgings per year of a particular forged part and we have to run our business considerably different when we do that than when we're making a thousand car sets per week of Corvette kinds of parts (10).

How Much Of Your Excess Capacity Could Be Used For DOD Aerospace Work If Required? This question was asked to determine if the allegations, from the literature review (Chapter II, p. 15), that a great deal of the excess capacity reported is, in fact, antiquated and unuseable for DOD aerospace work. All four forgers responded fully to this question. ALCOA reported "We are capable of utilizing all of our excess capacity to fulfill DOD aerospace needs" (10). They went on to report that "Our excess capacity is not old, broken or mothballed facilities. It is the unused hours of the primary equipment we operate and maintain day-in and day-out" (10).

Wyman-Gordon said that "virtually all" of their excess capacity could be used for DOD aerospace work (38). Ladish reported that 60 to 70 percent of their excess capacity could be used for DOD aerospace work (35). And Kropp forge reported that approximately 20 percent of their excess capacity would be useable for DOD aerospace work (27). With the exception of Kropp's response, the other interviewed forgers contradicted the allegation that much of the excess capacity is unuseable. One important point, brought out by Kropp specifically, is that what capacity is or is not useable depends on the particular product needing to be produced. Kropp does not have any of the very large presses and therefore none of their excess capacity would be useable for very large C-5 structural forgings. However, if the needed product is a smaller part then much more of their excess capacity would be useable (27). What is or is not useable depends on what is needed.

What Specific OSHA And EPA Regulations Have Impacted You The Greatest And What Has Been Their Affect? This question was asked because, based on OSHA and EPA being identified as contributing to long leadtimes in the literature review (Chapter II, p. 24-25) it was anticipated that there would be some specific regulations or acts that would have had a significant impact on the forgers interviewed. However, none of the forgers interviewed see OSHA or EPA as a problem, especially relating to an affect on leadtimes. As a result, the expected response to this question did not materialize. The information obtained from the question mostly applied to the fact that OSHA and EPA are not seen as problems to begin with, and is, therefore, discussed later in this chapter in the section dealing with OSHA and EPA as a problem contributing to longer leadtimes.

What Specific Products Do You Produce For Eventual DOD Use? This question was asked in order to get a better idea of what types of products

each of the interviewed forgers were producing. It was asked before the interviewer became aware of a near truth concerning DOD aerospace forgers: everybody makes parts for nearly everything. Any given forger produces hundreds or thousands of different parts. One forger reported that they may have as many as 4,000 active jobs at any one time. Asking the interviewees to identify all of these products was unrealistic and, therefore, was not done.

The products produced fall generally into two basic categories, structural parts and jet engine parts. Structural parts are usually much larger than engine parts and consist of items such as wing spars, pylons, and landing gears. Jet engine parts are usually made of more exotic metals and alloys in order to withstand the extreme temperatures and stress that is put on them. They include the rotating internal engine components, such as compressor and turbin disks, shafts, and hubs and non-rotating parts such as engine casings. The aerospace products produced by the forgers interviewed can almost always be categorized as either structures or engine components. ALCOA, Wyman-Gordon, and Ladish all reported that they produced both structural and engine parts (38; 10; 35). The specific ratio of structures to engine components varied from forger to forger but all have the capability to produce both types of parts. Kropp reported that what they produce today is primarily structural parts such as landing gears (27). However, they also have the capability to produce either structures or engine components depending on the specific dimensions etc. of the part (Kropp does not currently have any of the very large presses, isothermal forging, or hot isostatic pressing equipment) (27).

If For Another DOD Contractor, Who Is That Contractor? This question was asked to determine who the primary customers of the interviewed forgers were. It was asked, like the previous question, before the

interviewer became aware of another near truth concerning aerospace forgers: everyone produces parts for everyone. While the list of customers is not as extensive as the list of specific parts produced, it was still too long for each interviewed forger to bother reporting. Therefore, the forgers did not attempt, nor did the interviewer ask them, to give a complete listing. Off the tops of their heads each interviewee listed basically the same major customers. They included all the major prime contractors for aircraft and the major sub-contractors who produce components for the primes.

What was made clear from this question is that no forger or customer allows themselves to become too dependent on any one customer or producer. Furthermore, forgers are at nearly the bottom tier of the contractor hierarchy. Only raw materials or machine tool producers could be considered at a lower tier. Forgers essentially always produce a part to be used by another DOD contractor or sub-contractor higher up in the hierarchy. Even Wyman-Gordon, the largest DOD aerospace forger, reported that, aside from some research and development work, they have no direct contracts with the DOD for forgings; all forgings are produced for other contractors or sub-contractors (38).

What Are The Current Leadtimes For Those Products And What Have They Been In The Past? This question was asked to determine what each interviewed forgers current leadtimes are compared to the 1979-81 time frame and to see if their reported current leadtimes coincide with what has been reported by others. All four forgers responded to this question with essentially the same general averages for current leadtimes. ALCOA reported that they are currently averaging approximately 28 weeks to ship forgings. This is down from the 70 to 80 weeks ALCOA reported as their worst individual cases from the 1979-81 period (10). Wyman-Gordon

reported 28 weeks also for an average 50 to 75 piece order (38). This is down from 1979-81 leadtimes in excess of two years (124 weeks) on specific parts (Chapter II, p. 11). Ladish reported their current leadtimes to be from 6 to 9 months (24 to 36 weeks). This is not a change from their 1979-81 leadtimes, which they report to have also been 6 to 9 months (35). And, Kropp reported their current leadtimes to be approximately 26 weeks.

These reported leadtimes, on average, are significantly reduced from the actual leadtimes experienced during the 1979-81 time period. The responses from the forgers interviewed are essentially a consensus, and coincide very closely with current leadtimes reported by other sources. The leadtimes are essentially back down to the same level they were at in the 1977-78 time period, before shortages developed and leadtimes stretched out. Wyman-Gordon pointed out that current leadtimes are not only back down to the 1977-78 levels but they are at this level while production is at a level above that of the 1977-78 time period (38). The main fact brought out by this question is that leadtimes are significantly less today than they were in 1979-81.

What Is A Typical Process Flow, For Your Firm, From Initial Order Of A Forging To First Production Run? What Steps And Processes Occur; What Is The Time Involved; And What Is The Cost Of Each Step? (For Example, Initial Product Design, Die Production And Testing, Etc.). This question was asked to determine where in the forging process the bottlenecks causing long leadtimes were occurring. This question was impossible for the forgers to answer because, as previously mentioned, every product is different. Each product has its own unique set of processes. Each step or process has different costs and time parameters depending on that specific part. A process or step which is a constraint for one product may not be a constraint

for another. The basic processes, or steps, according to the forgers interviewed, are the same as those outlined earlier in this report (Chapter II, p. 10). ALCOA did present the interviewer with an example of a process flow for one particular part and it is contained in appendix IV (10). No specific times or costs are associated with the example, but it gives an excellent picture of the numerous steps that must occur and be coordinated in producing a forging.

Probable Causes And/Or Problems Responsible For Long Leadtimes

From the review of literature, thirteen problems and/or factors were identified as causing or contributing to excessive leadtimes to procure DOD aerospace forgings. In regards to each of the thirteen, the interviewed forgers were asked if they agreed or disagreed that it was, in fact, a problem that contributed to longer leadtimes during the "crunch" (1979-81 period), and if they believed it was still a problem. They were also asked to bring to the interviewer's attention and discuss any problem or factor not listed among the thirteen. In addition to the four forgers, selected individuals, with expertise in some of these thirteen areas, were sought out and interviewed in regards to that particular problem or factor. Where applicable the information obtained from these experts was used to supplement the responses of the forgers or the reasons for their responses.

Lack Of Capacity. This problem concerns the lack of enough capital equipment or use of current technologies to insure leadtimes are not excessive. All four forgers responded to this question. There were differences in the responses to whether lack of capacity was a problem which contributed to longer leadtimes during the 1979-81 time period, but a consensus as to whether they believed lack of capacity to be a problem in

1986. ALCOA reported that lack of capacity was a problem during 1979-81. The problem, according to ALCOA, was in the preform area. Preforming is the preliminary forging operation that gradually shapes the workpiece prior to it being forged in the final press or set of dies. ALCOA reported that there was a bottleneck due to a lack of preforming capacity, not a lack of large final press capacity (10). ALCOA did not think that lack of capacity is a problem today. It thinks there is a great deal of excess capacity currently available (10). Wyman-Gordon also thinks that lack of capacity was a problem in the 1979-81 period. However, it thinks the problem was, in fact, a lack of large press capacity. It thinks that more parts requiring the very large presses were being ordered than the available large presses could process (38). Wyman-Gordon does not think that lack of capacity is a problem today (38). Ladish reported that lack of capacity was not a problem in 1979-81 nor is it a problem today. It reported that it had excess capacity in 1979-81 and still does today (35). Finally, Kropp reported that lack of capacity was not a problem in 1979-81 or now. According to Kropp there simply is not enough business today to use the capacity that is already available (27).

Several important points, requiring elaboration, were brought out in discussing this area with the forgers and others. First, new capacity has been added in all types of equipment and technologies, industry wide, since 1979-81. One of the forgers interviewed reported that they had spent 125 million dollars for additional physical capacity and technological improvements since 1980. In the area of large press capacity, two of the interviewed forgers and Iron Age reported that at least three forgers have added large presses since 1980 (38; 10; 6). Specifically, Weber Metals (Paramount, CA) has added a new 38,000 ton press; Shultz Steel (Southgate,

CA) has added a new 28,000 ton press; and Cameron Iron Works (Houston, TX) has added a new 23,000 ton press (6:2). Second, both Wyman-Gordon and RMI Company (a titanium mill at which an interview was conducted) brought out the fact that increased use of castings and composites (kevlar, graphite-epoxy, and glass fiber reinforced plastics), as substitutes for forgings, have freed up additional capacity within the forgings industry (38; 36). Third, as brought out in the literature review (Chapter II, p. 7) net sales in the forging industry have decreased significantly since 1979-81, and this has also freed up additional capacity. All of these factors, new presses, increased use of substitutes, and decreased sales, have caused the current amount of excess capacity to be in the neighborhood of 40 to 50 percent (Chapter II, p. 15).

The last point requiring discussion is the view of non-forgers on this topic. Dr. Harold Gegel, Senior Scientist, Processing and High Temperatures Branch, Materials Lab, AFWAL/ML, and Brad Botwin, an economist with the Department of Commerce's Office of Industrial Resource Administration both think there are serious shortages in certain types of forging capacity (22; 7). Dr. Gegel thinks the shortages are in large presses and in technology. He stated that the "biggest barrier today is education to use the available technology" (22). The technology area he stressed most was CAD/CAM, which will be covered later in the report. Mr. Botwin's thoughts parallel Dr. Gegel's in that he thinks large press capacity and newer equipment are deficiencies requiring attention. Specifically, he is in favor of the 200,000 ton press (7). The U.S. forging industry does not currently possess this capability, while the European forging industry does. Mr. Botwin pointed out that some U.S. users of forgings are purchasing overseas in order to take advantage of that capability (7). The other side of this issue is, that forgers

generally do not feel this additional capacity and capability would be sufficiently utilized to make it economically worthwhile (38; 10; 27; 35). The cost of building a 200,000 ton press would be astronomical. Estimates run as high as one billion dollars apiece, and the industry would require at least two. Two would be required in case anything happened to render one or the other inoperable. Forgers fear that aircraft designers will resist designing parts for such a rare piece of equipment because of the risk of it becoming inoperable and then having no other capability in the U.S. to produce those parts (38; 10; 27; 35).

Lack Of Skilled Labor. This problem area concerns not having enough of the skilled labor necessary to process orders in a reasonable time period. All four forgers responded to this problem. There was a consensus as to whether lack of skilled labor was a leadtime problem in 1979-81; all four stated that it was (38; 10; 27; 35). However, the responses concerning whether lack of skilled labor is currently a leadtime problem differed. ALCOA reported that it does not see lack of skilled labor as a problem today but thinks it will become one again if another surge were to occur (10). It reported that due to major layoffs in the steel and auto industries in its area (Cleveland, OH), there is an abundant supply of labor. However, it also reported that, getting the people is not the problem, training them is. According to ALCOA, it will be able to see a surge coming, but even so, the time required to bring the new labor up to speed will take anywhere from 6 to 12 months. This, according to ALCOA, could cause a lag in the skilled labor pool that could affect leadtimes (10). Wyman-Gordon also reported that lack of skilled labor is not a current problem but would probably become one again in another surge (38). Its reasoning was identical to that of ALCOA. Wyman-Gordon reported that due to its own layoffs, and the layoffs of

others, there is also an abundant supply of labor in its area (central Massachusetts). But, the time required to train this new labor will be a limiting factor that could cause a shortage affecting leadtimes (38). Ladish did not think that lack of skilled labor is a current problem nor will it become one in any foreseeable surge (35). It reported that it has a ready supply of labor, and it thinks that six months is the maximum amount of time it will require to bring any additions to its labor force up to speed (35). Kropp not only thinks that lack of skilled labor was a problem in 1979-81, it reports that it is a problem today, surge or not. It brought out the fact that it currently has fifteen pieces of major forging equipment and a total of only ten to eleven forging crews. It reports that training time is extensive and will cause a lag that will affect leadtimes (27).

Two additional points were brought out by the forgers during the discussions concerning the lack of skilled labor. First, the current level of business in the forging industry is so low that the size of work force necessary to respond to increased levels of production simply cannot be maintained. This is apparent from the fact that half of the forgers interviewed are down to a fraction of their previous workforce (Chapter IV, p. 40-41). Therefore, in the event of a rapid increase in demand for forgings, a surge, a large number of new employees will have to be brought on and trained. With only one exception, all the forgers interviewed see the time required to train this new labor as extensive and believe it will have an adverse affect on leadtimes. Finally, one encouraging fact was brought out by the forgers and others. The new technologies and near net shape technologies, such as isothermal forging, hot isostatic pressing, and CAD/CAM, should reduce the amount of manual skill required of the labor force. This, in turn, will shorten the amount of time required to get new

labor up to speed in future surges.

Raw Materials Availability. This problem concerns the unavailability of, or excessive time required to procure, the raw materials necessary for production of forgings. Those interviewed were asked to respond to this problem area by specific raw material, either titanium or cobalt/chromium. In addition to interviews with the four forgers, one was conducted with Crystal L. Revak, Marketing Communications Manager for RMI Company, Niles, Ohio, one of the larger integrated titanium mill product producers in the United States.

Titanium. There was a consensus among the forgers interviewed as to whether titanium availability was a problem during the 1979-81 time period; all reported that it was a major problem which adversely affected leadtimes (38; 10; 27; 35). As to whether it is a current problem, all four reported it was not a current leadtime problem. ALCOA reported that, based on its assessment of the current capability of the titanium industry, it no longer views titanium availability as a problem. It brought out that some other forgers have integrated titanium production into their plants or organizations since the 1979-81 period. It reported that it feels secure enough in the capability of its suppliers that it does not see a need to integrate titanium production into ALCOA (10). Wyman-Gordon also reported that titanium availability is no longer a problem for them. In 1982 it integrated titanium production into the company with the purchase of an initial percentage of International Titanium, Inc. (Moses Lake, Washington). In 1986 it reports its interest in International Titanium to be 80 percent. In addition, a melt facility has been constructed at Wyman-Gordon's Millbury, Massachusetts facility. It reports that it is not yet completely self sufficient in titanium production and purchase from several suppliers, but with the

current capacity and capability of U.S. producers, and its own capability, it does not foresee titanium availability as being a problem again (38). Ladish reported that it no longer sees titanium availability as a leadtime problem. It reported that it is integrated into titanium production in that Oremet is a part of its corporate family. However, it, like Wyman-Gordon, purchases titanium from different producers (35). Kropp reported that titanium availability is not a problem for it today. It reports that it currently takes 10 to 12 weeks to receive its titanium (27).

Several additional points concerning this problem were brought out either by the forgers or in the interview at RMI Company. First, the shortages and excessive leadtimes for delivery of titanium during the 1979-81 period were short lived (38; 10; 36). The excessive quoted leadtimes were caused as much by panic ordering from the commercial sector as any real shortage of material (38; 10; 36). What occurred is that as producers of aircraft and other products, requiring titanium and high temperature alloy forgings, saw leadtimes begin to stretch out in 1979 and early 1980 they ordered ahead to try to insure their orders would get processed. They ordered far in advance of when they really needed to. They sometimes ordered before they had even been awarded the contract they were ordering against. In fact, there were times when more than one customer was placing an order against the same contract which only one contractor would receive. The affect was a tremendous backlog on the books of the titanium mills. Consequently, quoted leadtimes for mill products increased from a few months to more than a year in a very short amount of time (36). What eventually occurred was a large fall out of the double and triple ordering and panic ordering. When a particular contract was awarded the contractors who had ordered against it and then not received it cancelled

their orders. Also, the actual unusually high requirement for forgings decreased rapidly in 1982 (36). Figure 9 is a graph prepared by RMI which shows the actual amount of titanium mill products shipped from 1955 to 1985 (36). It is clear from this graph that the surge in titanium requirements came about very quickly and disappeared even more quickly.

Second, a large amount of new titanium producing capacity has been added since 1979-81. Again, graphs prepared by RMI will help in illustrating this point. Specifically, new sponge producing equipment and new melt furnaces for converting titanium sponge into ingot or billet have been added (36). And, at least one major producer has come into existence since 1980, that being International Titanium (Moses Lake, Oregon) (36). Figure 10, RMI's graph titled "Free World Titanium Market: Titanium Sponge Capacity" shows just how extensive the increase in overall free world (free world being the U.S., Europe, and Japan) capacity has been (36). The free world capacity has increased from approximately 120 million pounds annually in 1981 to approximately 150 million pounds in 1986 (36). Figure 11, RMI's "Free World Titanium Market: Titanium Sponge Production" graph clearly shows that current useage of titanium is far exceeded by the available capacity (36). In fact, in the peak year of 1981 current capacity would have exceeded requirements by nearly 35 million pounds. According to RMI, the significant shortages in the U.S. in 1979-81 were caused because U.S. requirements exceeded U.S. sponge capacity at that time (36). However, U.S. sponge capacity alone is now approximately 70 million pounds. This, according to RMI, is enough capacity to handle even the 1981 U.S. requirements without any input from Europe or Japan. The main point is that we now have excess capacity in the U.S. titanium industry. Figures 12 and 13, RMI's "Free World: Current Sponge Production/Capacity Utilization"

pie charts show that the U.S. industry is currently operating at approximately 65 percent of practical capacity, which translates to roughly 30 million pounds of excess capacity in the U.S. alone (36).

Finally, the increased useage of substitutes, such as castings (only for non-rotating parts) and composites (kevlar, graphite-epoxy, and glass-fiber reinforced plastics), and the decrease in scrap caused by the increased use of near net shape technologies, such as hot die forging, isothermal forging and hot isostatic pressing, have reduced the requirements for conventional forgings and, therefore the titanium requirements for the forging industry. Substitutes such as castings still require an equivalent grade of titanium as would have been used to forge the same part, but not as much. Composites would use no titanium at all. The near net shape processes still use the same titanium but require less of it due to less machining being required.

The bottom line concerning the titanium availability area is that it is no longer a problem. Leadtimes are down, ample capacity has been added, and domestic capacity is such that the U.S. is self sufficient. All the forgers interviewed and RMI contend that a titanium shortage situation, as occurred in 1979-81, should not reoccur (38; 10; 27; 35; 36).

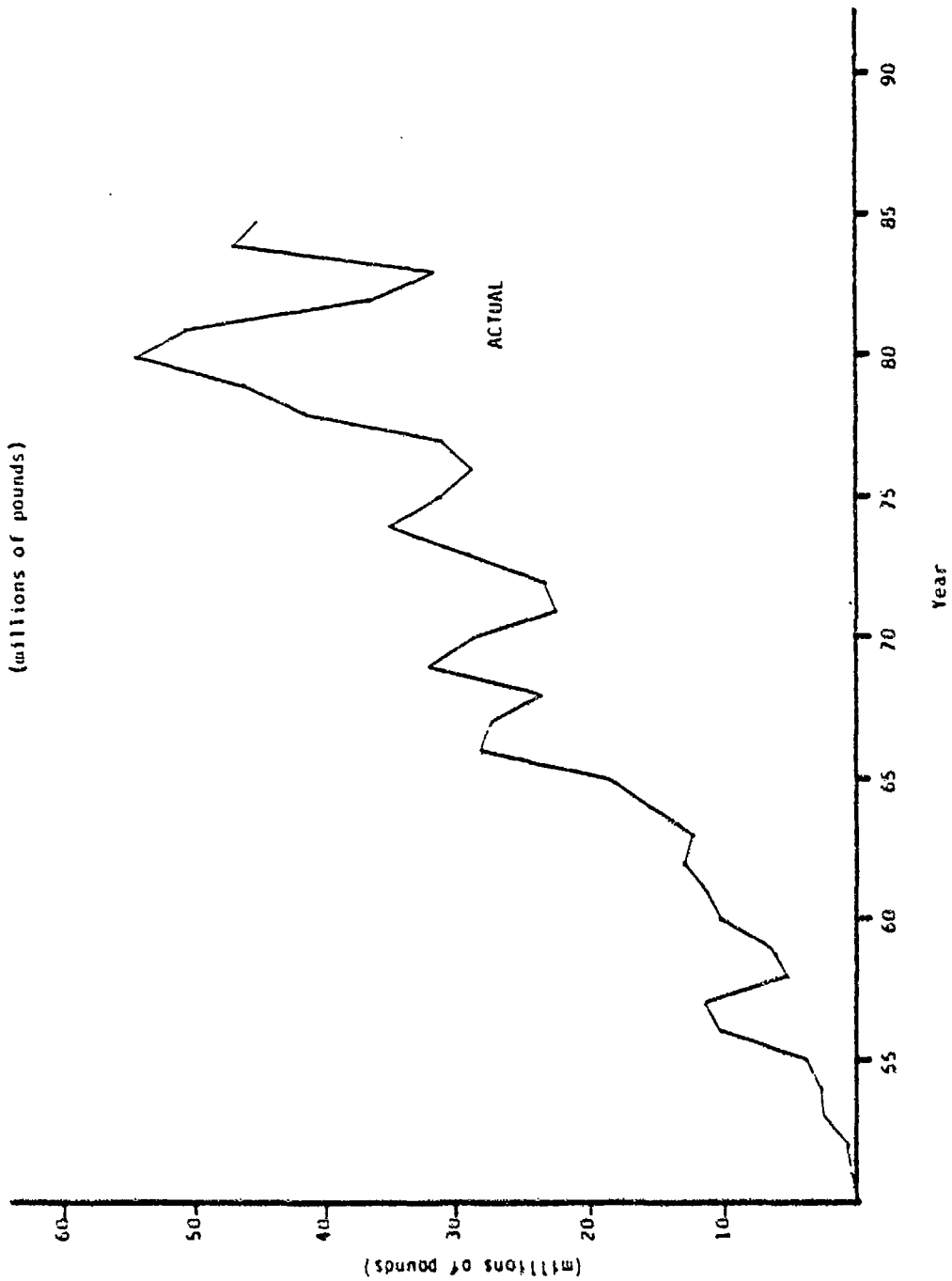
Cobalt/Chromium. There was a consensus response from all four forgers on this problem. They all reported that "it was a problem during the 1979-81 time period and nothing has changed" (38; 10; 27; 35). They all pointed out that the problem was not, and is not, one of physical shortages of material but rather getting the material delivered to the U.S.. The countries producing Cobalt and Chromium were politically unstable in 1979-81 and remain so today. As previously discussed (Chapter II, p. 20), Zaire supplies the majority of U.S. imports of cobalt and South Africa supplies most U.S. imports of chromium. The current internal strife in South Africa is a prime

example of this instability. At any given time civil war or other political problems could cause a complete collapse of these sources of supply. Therefore, while the current low level of business in the forging industry is not being adversely affected in any way, the potential for future problems continues to exist. Which brings up the next point, brought out by both Wyman-Gordon and Ladish, the use of existing alloys which depend less on cobalt as an alloying ingredient has been increased (38; 35). Two specific examples given were RENE-95 and INCO-718 (38; 35). RENE-95 uses 8 percent cobalt and INCO-718 uses no cobalt, whereas the alloys they are substituted for may use as much as 16 percent (38). While these alloys use less cobalt they still use large amounts of chromium (38). The chromium problem is unchanged from 1979-81. Wyman-Gordon reported that research is currently underway to develop alloys which use less, or none, of this metal (38). This is a significant trend considering the following statement made by F.I.A. in March of 1981:

Chromium and cobalt are important alloying ingredients for high temperature materials. Jet engines, for example, are highly dependent on titanium and stainless steel. A stainless steel that will withstand jet engine heat levels can't be made without chromium and cobalt as alloying ingredients (17:3).

The main point concerning cobalt and chromium availability is that it is a problem domestic users of these metals have little or no control over. Therefore, although it is currently not a problem, U.S. firms are attacking the potential problem in order to make it one they can have control over. By substituting alloys which use no, or less, cobalt, and by working to develop alloys which will not be as dependent on chromium, they are creating a way to work around and eliminate their dependence on these metals.

A HISTORY OF THE TITANIUM INDUSTRY
IN TERMS OF MILL PRODUCT SHIPMENTS
(millions of pounds)



As of March, 1986

Figure 9. Titanium Mill Product Shipments: 1955-1985
Reprinted By Permission of RMI Company (36)

FREE WORLD TITANIUM MARKET TITANIUM SPONGE CAPACITY

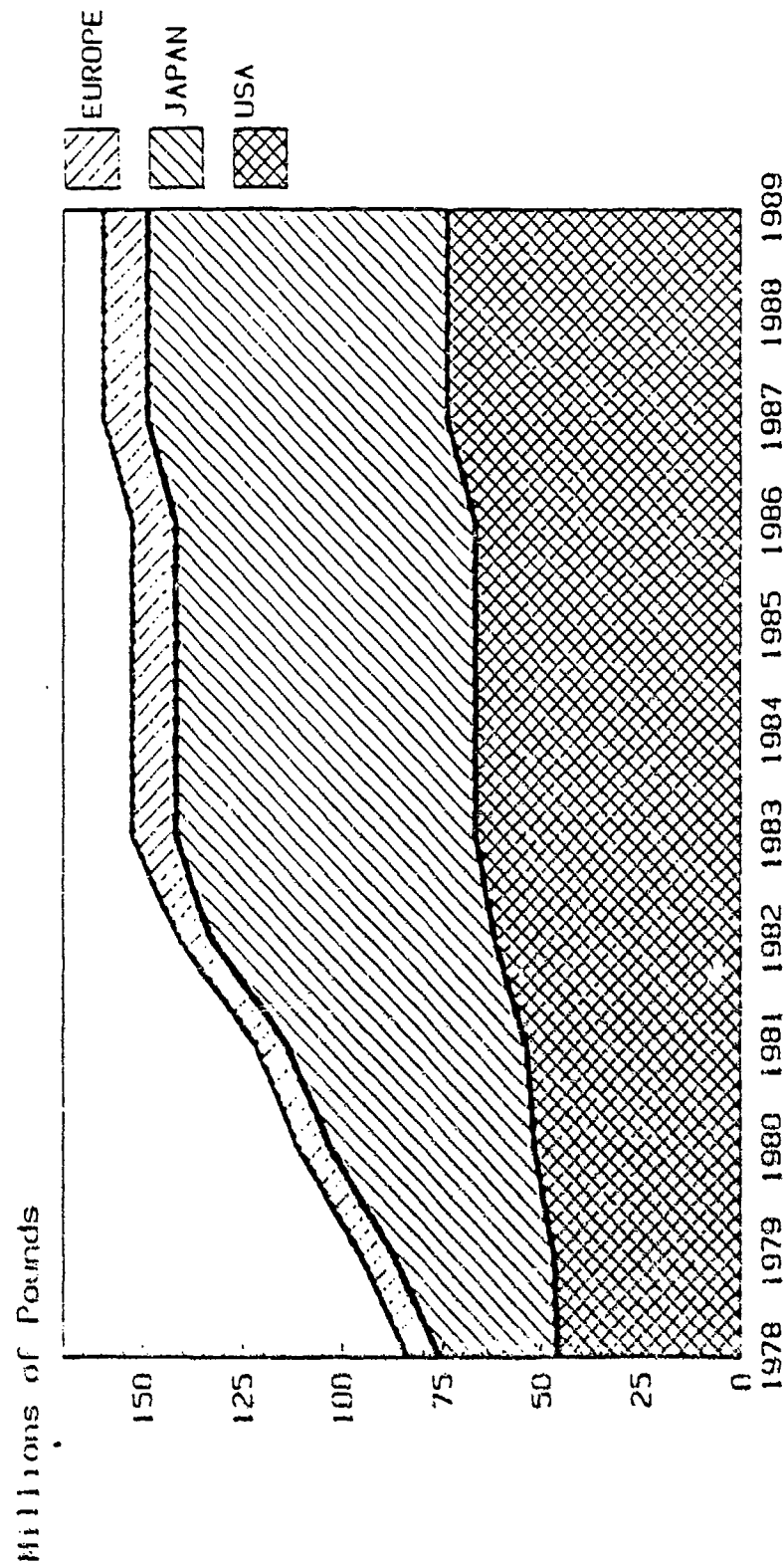


Figure 10. Titanium Sponge Capacity
Reprinted By Permission of RMI Company (36)

FREE WORLD TITANIUM MARKET TITANIUM SPONGE PRODUCTION

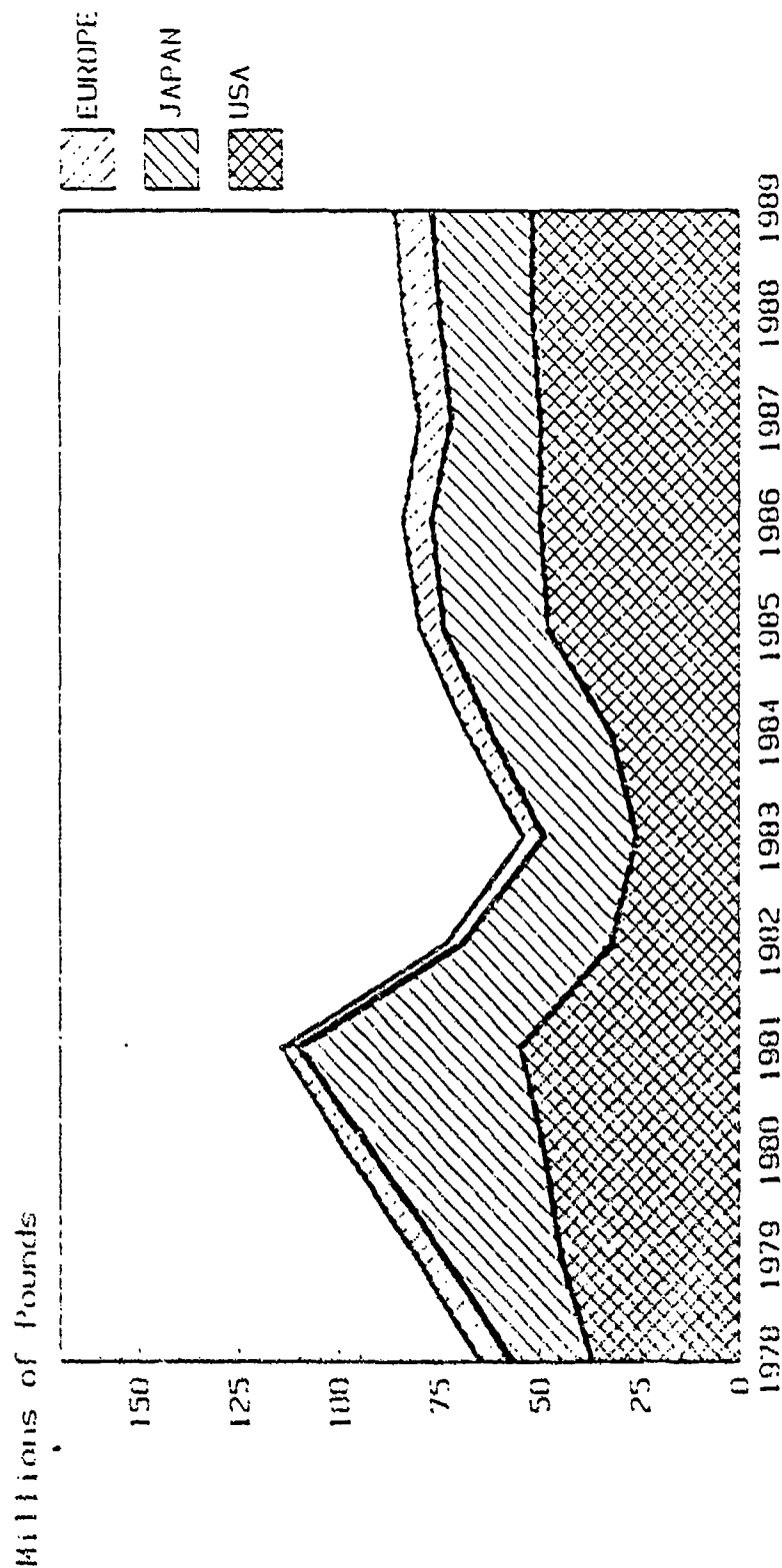


Figure 11. Titanium Sponge Production
Reprinted By Permission of RMI Company (36)

FREE WORLD CURRENT SPONGE PRODUCTION/CAPACITY UTILIZATION

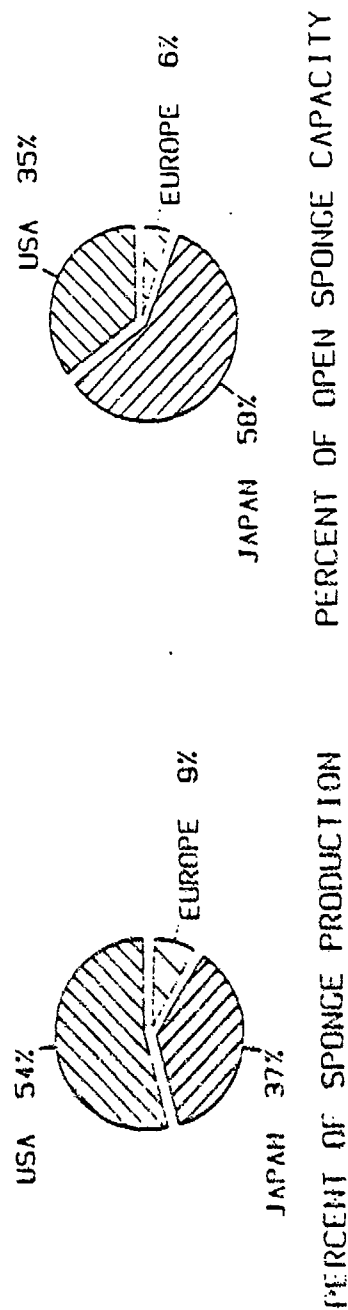
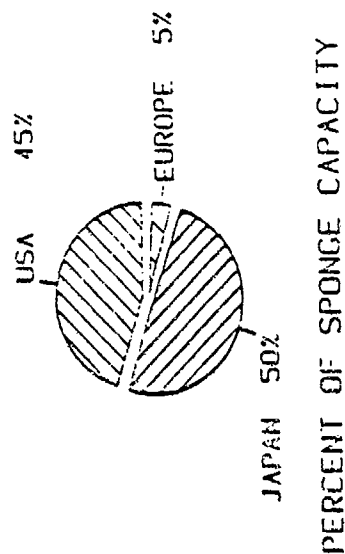


Figure 12. Titanium Sponge Production/Capacity Utilization (percentage)
Reprinted By Permission of RMI Company (36)

FREE WORLD CURRENT SPONGE PRODUCTION/CAPACITY UTILIZATION

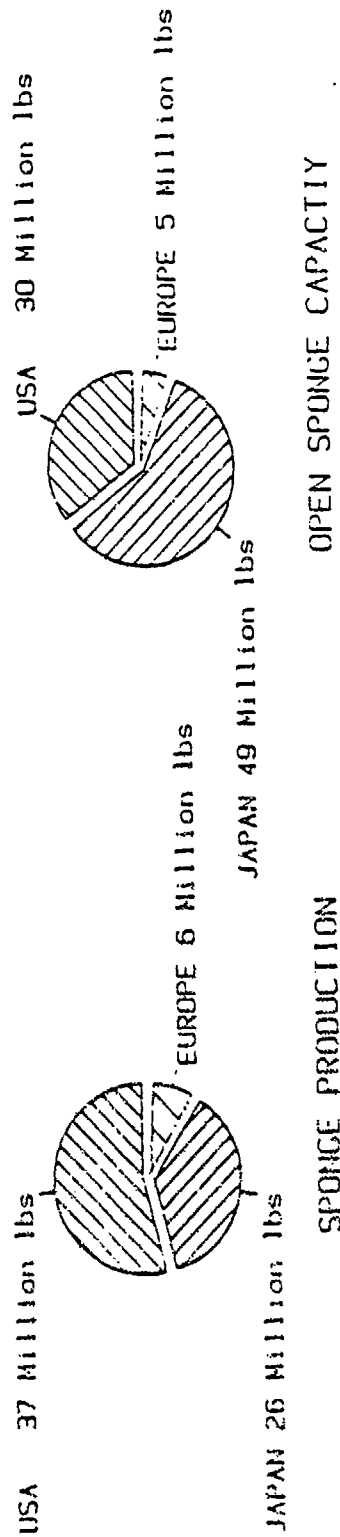
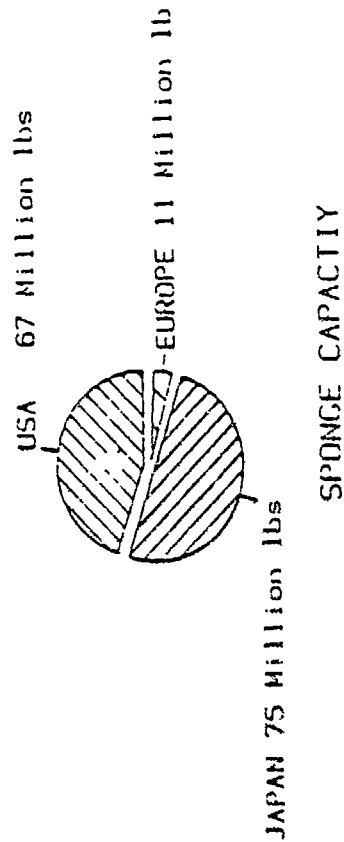


Figure 13. Titanium Sponge Production/Capacity Utilization (pounds)
Reprinted By Permission of RMI Company (36)

Defense Priorities And Allocation System (DPAS) Misuse Or Non-Use.

This problem concerns the loss of possible reductions in queue leadtime by not taking full advantage of the benefits of the DPAS. In addition to the four forging firms, an interview was conducted with Richard V. Meyers, DPAS Program Manager for the U.S. Department of Commerce's Office of Industrial Resource Administration. The DPAS went into effect on 29 August 1984 and combined and replaced the Defense Priorities System (DPS) and the Defense Materials System (DMS) (33:V). The interviewer was unaware of DPAS at the time of the forging company interviews and the forgers were questioned on the DPS and DMS separately. Therefore, their responses are presented separately, as the materials allocation portion of DPAS (DMS) and as the production priorities portion of DPAS (DPS).

Misuse Or Non-Use Of The Materials Allocation Portion Of DPAS.

None of the forgers interviewed responded on this topic as it was not applicable to them since they do not get involved in the materials allocation portion of DPAS. However, Richard Meyers is involved with the materials allocation portion of DPAS and responded to the following point brought out in the literature review (Chapter II, p. 21). There was concern over the fact that the materials which were most critical to the forging industry and in the shortest supply in 1979-81, titanium, cobalt, and chromium, were not included in the Defense Materials System (now materials allocation portion of DPAS). Mr. Meyers explained that it would serve no purpose to include them; no benefit would be gained (31). The reasoning behind this statement has to do with the general purpose, or goal, of both the production priorities and the materials allocation portions of the DPAS. The production priorities portion of the DPAS is intended to insure that DOD contractors, producers of products or components of end products for DOD use, produce rated DOD

orders on time in accordance with their contracts. If necessary, they are expected to give preferential treatment to rated orders to insure they are delivered on time. This may necessitate bumping commercial orders or other DOD orders with lower ratings. Whatever it takes, contractors are mandated by law to deliver on time if physically possible. For example, a forger has a DX rated order which must be delivered by a certain date. He currently has a commercial order which was scheduled before the rated order and requires the use of the same equipment for production. He cannot produce both orders on time; one must be delivered late. Under the DPAS that contractor must produce the rated order and bump the commercial order regardless of whether it was scheduled first, regardless of whether it is his best customer, and regardless of whether he will be sued for damages by that commercial customer. The materials allocation portion of the DPAS, on the other hand, does not deal with products and contractors but the raw materials used to produce products. It is designed to insure that raw materials are allocated to the proper industry or product, as opposed to contractor capacity being allocated to the proper contract. For example, aluminum or steel might be withheld from domestic auto makers and reallocated to DOD aircraft or tank manufacturers. Now, the reason that titanium, cobalt, and chromium are not included in the materials allocation portion of DPAS is because there is no competition for those raw materials. Non-aerospace requirements for those materials are so limited that they pose no threat to the allocation of those raw materials to the proper defense industries. Mr. Meyers stated that the problem with those materials is getting them into the U.S., not allocating them to the proper industry once they are here. Therefore, in Mr. Meyers opinion, controlling those materials once they are in the U.S. would serve no purpose (31). The question the

researcher still has is how to insure commercial aircraft production does not compete with defense aircraft production for these materials.

Misuse Or Non-Use Of The Production Priorities Portion Of DPAS.

There was a consensus response from all four forgers to whether this was a problem which adversely affected leadtimes for forgings. They all reported that this was never a problem, is not one today, and that they have always used the old DPS and now DPAS (38; 10; 27; 35). Additionally, while all four reported using the systems, only one forger, Ladish, reports ever having bumped a commercial order to process a rated order (35). These responses contrast with the information contained in the literature review (Chapter II, p. 21).

Mismanagement Of The Stockpile Of Strategic Materials. This concerns the loss of possible reductions in queue leadtimes by not using the stockpile to help relieve shortages, such as occurred in 1979-81, and the possible obsolescence of the materials contained in the stockpile. While some of the forgers had personal opinions and beliefs concerning this area, all chose not to respond due to their lack of direct experience in this area (38; 10; 27; 35). However, information on this topic was obtained from two supplemental interviews, one with Paul J. Halpern, Strategic Materials Program Manager for the U.S. Department of Commerce's Office of Industrial Resource Administration, and the previously mentioned interview with RMI Company.

Neither of the interviews produced reportable responses concerning whether queue leadtimes could have been reduced in 1979-81 as a result of releasing stockpile material. However, both individuals responded on the issue of obsolescence of stockpiled materials. RMI reported that "the stockpiled titanium sponge is not adequate" (36). Mr. Halpern (Dept of Commerce) reported that "some materials are, in fact, technologically

obsolete" (24). The reason given for this obsolescence is that over time the materials become technologically inferior to current materials (36; 24).

Technological obsolescence comes about when materials that are as much as 20 years old are sitting in the stockpile. Advances in metalurgy have vastly improved the quality and purity of the metals and alloys being used today. Older material in the stockpile is simply not up to current specifications and is not usable as is (36). In order to use much of the outdated material it would have to be reprocessed (24). There is an ongoing debate as to what the best form of product to stockpile is. In other words, in the case of titanium, would it be best to stockpile rutile (raw sand like ore containing titanium), sponge (pure processed titanium), or mill products like ingot and billet (blocks and bars of semi-finished titanium mill products). Currently, titanium is stockpiled in the form of sponge (36; 24). This is a more versatile form, with a smaller chance of technological obsolescence than finished mill products (36; 24). However, one final point was brought out by Mr. Halpern concerning the stockpiling of finished mill products. Stockpiling finished product would also stockpile energy, labor, and transportation costs and time (24). This would be a distinct advantage if the stockpiles were ever needed in a surge situation. RMI reported that current industry delivery times for forging industry mill products is only 8 to 12 weeks (36). Stockpiling finished mill products would completely eliminate this 8 to 12 weeks of leadtime.

Single Year Government Funding. This concerns the reluctance of forging firms to invest in expanded capacity and capability based on uncertain, one year contracts. It includes new capital equipment, to either modernize or expand capacity, and an increased labor force. All four forgers responded on this topic. Three of the four forgers (ALCOA, Ladish, and

Kropp) reported that single year funding was not a problem which adversely affected leadtimes in 1979-81, nor is it a problem today (10; 27; 35). These firms reported that whether a particular contract for a DOD item was for one year or more than one year, it did not affect their capital expansion or labor force expansion decisions (10; 27; 35). One firm, Wyman-Gordon, reported that single year funding was a problem which adversely affected leadtimes in 1979-81 and could still affect them today (38). However, its reasoning did not involve capital or labor force expansion. Wyman-Gordon thinks single year funding to be a problem because it takes some of options for production efficiencies away from the forger (38). For example, 50 of a particular part are required each year. Yearly funding leaves the forger one option, produce fifty this year for delivery this year. However, if the funding was for three years worth of the part (150) then the forger would have options besides producing 50 in each of three years. Based on that particular forger's capacity and capability he might find it more efficient to produce all 150 in one production run the first year and inventory the additional 100 parts for the following two years. Likewise, he may decide to produce all or part of the order at any specific time as a means of leveling out his business, thereby, stabilizing and maintaining his workforce. The main point made by Wyman-Gordon is that the forger has fewer options available to him the shorter the contract (funding time frame) is (38).

Except for Wyman-Gordon, the responses received from the forgers on this topic disagree completely with the information in the review of literature (Chapter II, p. 22-23). Even though Wyman-Gordon did agree that single year funding was and is a problem, their reasoning for this response is completely different than that given in the literature review.

Military Specifications. This concerns the belief that, compared to

commercial specifications, more stringent military specifications slow down the production process. There was a consensus among the forgers on this topic. ALCOA, Wyman-Gordon, Ladish, and Kropp all reported that military specifications never have been and are not currently a problem which adversely affects leadtimes. The points brought out by the forgers were first, that there is no difference between commercial aerospace specifications and military aerospace specifications. Aerospace specifications are the same for military parts and commercial parts (38; 10; 27; 35). Second, while complying with some aerospace specifications may be expensive and sometimes inconvenient, it is much less expensive and inconvenient than the consequences of not complying. The cost of scrapping or reworking a part, or the damages should a part fail, far outweigh the cost of complying with aerospace specifications (38; 10; 27; 35). The responses from these four forgers contradict the information contained in the literature review (Chapter II, p. 23-24).

Supplier Qualification Requirements. This concerns the problems faced by firms trying to do business with the government for the first time. All four firms stated that this area was not applicable to them since they had all been doing DOD business for many years (38; 10; 27; 35). However, a point which came out in the discussion of this topic is that, as already mentioned, all orders are commercial to the forgers. Therefore, any forger who can do commercial aerospace work can do DOD aerospace work. Forgers are sub-contractors producing for the primes. It is the primes who have to get qualified by the government and go through the bureaucratic nightmares, not forgers. This view also contradicts the information presented in the literature review (Chapter II, p. 23-24).

OSHA And EPA Regulation. This concerns the possible extension of

leadtimes due to OSHA and EPA regulation. Specifically, extensions due to the additional time and expense of making modifications or additions in order to comply, or the loss of capacity due to closings of firms who cannot afford to comply (see appendix I for a list of closings). There was also a consensus among the forgers on this topic, which was that no OSHA or EPA regulation has had, or is currently having, an adverse affect on leadtimes (38; 10; 27; 35). In fact, the forgers generally feel that the OSHA and EPA regulations are justified. Kropp reported that "OSHA and EPA required capital expenditures and programs have been justifiable from humanitarian, safety, and efficiency standpoints" (27). The forgers brought out that compliance can be very expensive and inconvenient and may even slow down the installation of new facilities and/or equipment, but there is no adverse effect on current leadtimes (38; 10; 27; 35).

Inefficiencies Caused By Use Of Government Furnished Plants Or Equipment. This concerns the government providing facilities and/or equipment to forgers, which may act as a disincentive to private capital investment. All four forgers interviewed responded to this topic but the responses differed slightly. ALCOA reported that this was not a leadtime problem in 1979-81. It had a heavy press shop owned by the Air Force but purchased it from the Air Force in the 1982 time frame. It reported that it was not a problem because the Air Force plant was kept up just as well as if it had been privately owned (10). Wyman-Gordon also had a heavy press plant which was Air Force owned. It reported purchasing that facility from the Air Force in the 1981-82 timeframe. It reported that its government owned equipment did not adversely affect leadtimes prior to its purchase of it. Its reasoning was identical to ALCOA's, in that, its Air Force owned facility was up to date and maintained as well as if it had been privately

owned (38). Ladish also had government owned equipment, and like ALCOA and Wyman-Gordon, has purchased it from the Air Force since 1980. Ladish reported that government owned or furnished equipment was not a problem which had any adverse affect on leadtimes. However, it reported that it thinks the firm using government owned equipment can have an unfair competitive advantage. Without an investment in capital equipment to recover, the firm using government equipment can produce at a lower cost than the firm using its own equipment (35). Kropp also has some government owned equipment. It reported that it has already purchased some of that equipment and is in the process of purchasing the remainder. It reported that government owned equipment did not adversely affect leadtimes in any way. It sees no difference between using a government asset or private asset, so far as leadtimes are concerned (27). The forgers interviewed generally disagreed with the information contained in the literature review on this topic (Chapter II, p. 27-28). They do not believe that the government owned equipment was antiquated or inefficient (38; 10; 27; 35).

Imports. This concerns the loss of sales to offshore competition. There was a consensus among the interviewed forgers concerning whether imports were a problem affecting aerospace forgers in the 1979-81 period; none of the them reported imports as being a problem which impacted their leadtimes for DOD aerospace sales (38; 10; 27; 35). However, their responses as to whether imports are a current problem differ. ALCOA reported that imports may now be a problem (10). Wyman-Gordon reported that imports are a current problem and they specifically blame Japanese competition for the recent closure of their Harvey, Illinois crankshaft plant (10). Ladish reports that imports are a current problem, but not in their DOD markets

(35). Kropp reported that imports are a current problem for them (27). The forgers generally agreed with the information in the literature review (Chapter II, p. 26-27) in that imports are aimed primarily at the commercial sectors of the forgings market, not the aerospace sector (38; 10; 27; 35). This does not mean that they are unaffected though. All these forgers are also involved in the commercial markets and increased offshore competition is cutting into their profit base. One forger reported that increased import competition in commercial markets is causing more and more forging firms, previously not involved in the DOD aerospace markets, to enter the DOD market as a means of economic survival. According to this forger, the DOD market currently offers a haven where domestic forgers are protected from foreign competition. While imports do not directly threaten DOD aerospace markets the additional firms entering the DOD market are an indirect form of additional competition caused by the imports.

Offsets. Offsets are a problem, not specifically covered in the interview guideline, which every single interviewee, forger and non-forger, brought to the interviewer's attention. They are a special type of import problem which warrants being discussed separately. An offset is, as a condition of sale, an agreement between a domestic firm and a foreign customer, to either market some other product for the foreign customer or to allow the foreign customer to replace certain components of the item with their own. As an illustration of the first type, marketing a product for the foreign customer, the following paragraph from the 24 March 1986 issue of American Metal Market/Metal Working News is presented:

"Offsets" connected with overseas sales of American-made military equipment have received scant public attention to date, but are emerging as a growing problem that adds billions of dollars to the U.S. trade deficit, House Energy & Commerce

Chairman John D. Dingell told a National Press Club luncheon last week. Offsets are deals where the buyer forces an arms salesman to take non-defense products in partial payment to be resold later--often in the American market. As a result of such deals, many major U.S. contractors "find themselves peddlers of shoes, textiles, grapes, wine, furniture, and cosmetics--to cite only a few examples," the Michigan Democrat said. "Indeed, because of its offset agreement with Brazil, one major defense contractor may end up rivaling Gucci and Pappagallo as one of the world's foremost shoe marketers." And in some cases, he said, the imported offsets actually exceed the total sales value of the military hardware (51:4).

The other type, replacing certain components with their own, is best seen in the current sale of the F-16 to our NATO allies. It is referred to as a co-production agreement, which is another way to say "offset". The foreign governments refused to purchase the F-16 unless these concessions were granted. The U.S. government agreed, and the result is that every component produced for the F-16 by a foreign country and every hour of labor performed by a foreign worker is a direct reduction in revenue and wages to the producer and workers of the domestic firm who originally produced that component. Just how large an impact offsets will eventually have has not been determined but domestic forgers are very concerned. They view these types of agreements as a form of unfair competition.

Suggested Solutions, Or Fixes, For Long Leadtimes

From the review of literature, thirteen possible solutions, or fixes, for excessive leadtimes were identified. In regards to each of the thirteen, each forger interviewed was asked if they agreed or disagreed that it would have been a viable solution to excessive leadtimes during the 1979-81 period; if they have actually experienced or know of that particular solution being implemented; and if they feel it would be a viable solution today. They were also asked to bring to the interviewer's attention any possible solution not

listed among the twelve. In addition to the four forgers, selected individuals were sought out and interviewed. Where applicable the information obtained from these experts was used to supplement the responses of the forgers or the reasons for their responses.

Multi-Year Funding (Whole Program & Passed Down From The Prime Contractor To The Forger). This involves funding programs for more than the typical one year. For example, contracting for three or five years equipment with one contract. The most notable example of what this is expected to accomplish has been the F-16 program, which is heralded as having saved large amounts of DOD funds due to the increased efficiencies from a large guaranteed purchase. In regards to forgers, the belief is that they will expand their capacity and labor forces based on the multi-year guarantees. All four forgers responded, but only one, Wyman-Gordon, wanted it or thought it would make any real difference. It wants multi-year funding. It reported that it thinks multi-year funding will give it greater control over the efficiency of its operation, will lower the cost of its products to the DOD, and will help it maintain a more stable labor force (38). It is important to point out that although Wyman-Gordon wants multi-year funding it did not report that it would encourage it to expand either its capacity or labor force. When asked if it had experienced multi-year funding Wyman-Gordon said it had. It reported that in 1979-81 almost none of its orders were for multi-year programs and approximately 15 percent are today (38). Of the other three forgers, one reported that it did not want multi-year contracts at all and the other two reported that they did not feel there would be any real benefit from multi-year contracts (10; 27; 35). Two points were brought out which explain their responses. First, all the benefit of a multi-year contract goes to the prime contractor; little if any filters

down to the forgers at the sub-contractor level. One firm reported that it quite often is not even aware if a specific order is against a multi-year contract. It was brought out that while the prime contractor may in fact have a three or five year contract, it quite often deals with the sub-contractor in the same manner as if it had yearly contracts. The forgers are either asked to produce the entire three year quantity at on time or they negotiate yearly contracts with the primes just as before. The forgers do not gain any added control over their operations in this way. The forgers gain nothing from the multi-year contract. Second, the percentage of any forging firm's business made up by a single DOD contract is such a small percentage that it alone would never act as an incentive to expand capacity or the labor force. One firm reported that the largest single DOD program it produces parts for amounts to no more than two percent of its total business. One firm made the following statement concerning the affect any one DOD program has on a forger as compared to a prime contractor:

Take the F-16 away from General Dynamics and they have a great big hole. Take the F-16 forgings away from _____ and we have a little hole, because any one single program is a very small part of the total activity going on here.

Finally, as mentioned earlier (Chapter IV, p. 48), the number of any given DOD part produced each year is quite small compared with commercial orders. In fact, one firm reported that they could "forge three years parts (a three year supply) in a few days for most programs". In general, the forgers, with the exception of Wyman-Gordon, do not feel that multi-year funding will benefit them directly. Even Wyman-Gordon does not believe it will result in increased capacity and labor forces as suggested in the literature review (38).

Component Multi-Year Funding (Direct Multi-Year Contract For A Single Component, Whole Program Not On Multi-Year). This involves letting multi-year contracts for selected long leadtime and/or critical items only. The entire program would not be on a multi-year basis with the prime contractor, but rather sub-contractors of the selected items would have multi-year contracts directly with the DOD. The responses of the forgers interviewed were the same as for multi-year funding of the entire program. Wyman-Gordon thought the idea was great but reported that they not only have not seen a component multi-year contract; they had not heard the term or concept until explained to them by the interviewer (38). As for the other three forgers the response was the same; it will not have any affect on leadtimes, increasing capacity, or expanding the labor force (10; 27; 35). However, the argument that only prime contractors benefit is no longer valid. The argument concerning the small percentage of a firms business made up by a single contract does apply.

Income Tax Credits For Capital Expansion Investments And/Or Increased Depreciation Allowances On New Capacity. This concerns increasing income tax credits and depreciation allowances in the belief that this will increase investments in new capacity and larger work forces. Again, the focus is on attacking long leadtimes with increased capacity. However, the forgers do not perceive capacity as a current problem (Chapter IV, p. 53-55). ALCOA reported that increased income tax credits and depreciation allowances would have made no difference in their decisions to invest in additional or modernized capacity in 1979-81 and it will make no difference today. They report they would have made the same investments with or without these policies. Any affect these two policies would have had in the past or will have in the future is only in the degree of the investments

(10). Wyman-Gordon reported that these policies would have made and will make no difference in their investment decisions. They are icing on the cake, but the same investments would have been made with or without them (38). Ladish reported that these type of policies might help to influence some additional investment. However, in their particular case they would have made the same investments with or without them (35). Kropp reported that these types of policies would make absolutely no difference in their investment decisions. They reported that they do not have enough business currently to invest in increased capacity or capability no matter what (27). The general point made by the forgers is that these types of policies are a nice added attraction, but none of them would make, or not make, investments based on them.

Initial Provisioning ("Up Front" Purchases) Of Spares. This would involve the purchasing of a significant percentage of the anticipated spares requirements of critical and/or long leadtime parts initially. The desired result from strengthening firms financially through these advance purchases would, again, be increased investment in capacity and the labor force. Three of the four forgers interviewed gave identical responses to this question. ALCOA, Ladish, and Kropp all reported that they felt this might help, but they had not seen or experienced this practice yet (10; 27; 35).

Wyman-Gordon reported that it might help, but brought out the possibility of it backfiring and increasing the effect of the business cycle. The initial purchases would cause fewer replacement parts to be purchased in the future. Therefore, the "feast or famine" effect, already present in the forging industry as a result of the business cycle, might be amplified by additional initial purchases (38). Two additional points brought out by all the forgers require discussion. First, from the forger's experience, spares requirements

are very hard to accurately determine in advance. And secondly, the actual number of additional spares would most likely be an insignificant number in the first place (38; 10; 27; 35). For example, on a C-5A part which ALCOA produces only 16 of a year, an additional up front spares purchase of as much as 50 percent would only increase the annual production run to 24 pieces. The additional revenue generated by 8 parts is not going to have any impact on ALCOA or anyone else unless the additional purchases are authorized for a more significant percentage of that firms DOD items.

Eliminate Government Owned And Contractor Operated (GOCO) Plants And Equipment. This involves either selling or scrapping the government owned plants and equipment in use in the forging industry. The goal of which would be encourage private sector investment in newer technology and expanded capacity. All the forgers responded essentially the same as they responded to the problem of "inefficiencies caused by use of government owned and contractor operated plants and equipment" (Chapter IV, p. 74-75). ALCOA reported that it purchased the Air Force heavy press plant in 1982. However, it thinks that its purchase of the Air Force plant will make no difference in leadtimes for forgings. ALCOA contends that the Air Force maintained the plant as well as it would have. And it also contends that the equipment was not, and is not, antiquated or inefficient (10). Wyman-Gordon's response was identical to ALCOA's. It reported that it purchased its Air Force heavy press plant in 1981-82. It has not, and probably will not, improve its leadtimes. Wyman-Gordon reports that the Air Force maintained the plant well, and the capital assets are neither antiquated or inefficient (38). Ladish reported that it has purchased all of the government equipment it possessed. It reported that the only effect this type of action will have is to eliminate possible unfair competitive

advantages firms possessing a great deal of GOCO equipment might have. It will not affect leadtimes in any way (35). Finally, Kropp reported that it is currently in the process of purchasing back the GOCO equipment it has. Kropp also does not think this will affect leadtimes in any way. The belief that forgers would completely replace the GOCO equipment with newer technology equipment and increase their capacity has not materialized. The reason is that, as discussed in the section on the age of capital (Chapter II, p.43-44), the forgers report that even their oldest equipment has been rebuilt and/or modified and brought up to reasonably current technology (38; 10; 27; 35).

Make Better Use Of The Defense Priorities And Allocations System (DPAS). This would involve increased application of the DPAS. The belief being that leadtimes could be reduced by forcing forgers to produce DOD orders ahead of commercial orders, and by diverting raw materials from commercial industries to the forging industry. The forgers responded separately concerning the Defense Materials System (DMS), which is now the materials allocation portion of DPAS, and the Defense Priorities System (DPS), which is now the production priorities portion of the DPAS. In addition to the four forging firms, an interview was conducted with Richard V. Meyers, DPAS Program Manager for the U.S. Department of Commerce's Office of Industrial Resource Administration.

Make Better Use Of The Materials Allocation Portion Of The DPAS. None of the forgers interviewed responded on this topic because it was not applicable to them. They do not get involved in the materials allocation portion of DPAS. Mr. Meyers' response was that the materials allocation portion of the DPAS serves little or no function in today's economy. He feels this portion of the DPAS should be scrapped (31). As discussed earlier in

this report (Chapter IV, p. 68-69), today's critical forging materials are not only not included in the materials allocation portion of the DPAS, there is very little competition from commercial markets for them. In Mr. Meyers' opinion, changes in the useage of the materials allocation portion of the DPAS will have no affect on forging leadtimes (31).

Make Better Use Of The Production Priorities Portion Of The DPAS.

There was a consensus among the interviewed forgers on this topic; they all reported that better use cannot be made of the DPAS because they already comply with it fully. They do not believe this action would have any affect on forging leadtimes (38; 10; 27; 35). Mr. Meyers disagreed. He reported that not all forgers comply fully at all times. Therefore, he feels that better use could be made of this portion of the DPAS (31). The biggest concern of every interviewed forger on this topic was the liability question. Who protects the forgers from lawsuits initiated by commercial customers whose contracts have been violated due to the forger bumping their orders to process DOD rated orders (38; 10; 27; 35)? Mr. Meyers made it very clear that the forgers are completely protected from this type of litigation by the provisions of the DPAS (31). The Department of Commerce's pamphlet on the DPAS clearly states:

A person shall not be held liable for damages or penalties for any act or failure to act resulting directly or indirectly from compliance with any provision of this regulation, or an official action, notwithstanding that such provision or action shall subsequently be declared invalid by judicial or other competent authority (33:28).

Rotate National Stockpile Of Strategic Materials. This would involve a regular replacement of stockpile materials by selling the existing stock and replacing it with the revenues from those sale. The goal of which would be

to reduce leadtimes for raw materials when shortages appear and to eliminate the problem of obsolescence of the material in the stockpile. In addition to the forgers an information on this topic was obtained from interviews with Paul J. Halpern, Strategic Materials Program Manager for the U.S. Department of Commerce's Office of Industrial Resource Administration, and RMI Company. ALCOA reported that they feel this may help reduce leadtimes but, it will definitely help eliminate the problem of obsolete materials in the stockpile (10). Wyman-Gordon reported that stockpile rotation would have definitely helped reduce leadtimes in the 1979-81 period but would have little impact today because the titanium problem has been solved. They feel rotation will eliminate the problem of obsolete material within the stockpile (38). Ladish reported that rotation of the stockpile would probably reduce leadtimes in times of shortages of the stockpiled materials. They feel that stockpile rotation needs to be accomplished to eliminate obsolete materials (35). Kropp reported that it probably would help reduce leadtimes and that it needs to be done for the elimination of obsolete material (27). RMI reported that stockpile rotation must be accomplished because some of the material is already obsolete (36). Finally, Mr. Halpern pointed out that the entire stockpile program is currently under review and rotation is an issue being discussed (24). Generally, those interviewed believed rotation would have made a noticeable difference in forging leadtimes in the 1979-81 period, but due to current raw material leadtimes being vastly reduced from the 1979-81 levels, reductions in current forging leadtimes would be minimal. On the issue of obsolete materials, every forger and individual interviewed thinks that rotation would eliminate any obsolete material problem that exists.

Make Stockpile Access Easier. This would involve making access to

the stockpile during shortages quicker and less cumbersome (Chapter II, p. 21-22). In addition to the forgers, information on this topic was obtained from an interview with Paul J. Halpern, Strategic Materials Program Manager for the U.S. Department of Commerce's Office of Industrial Resource Administration. ALCOA and Ladish gave identical responses. They reported that this might have helped reduce leadtimes during the 1979-81 time frame, but they are unsure of what the impact would be today (10; 35). Wyman-Gordon and Kropp also gave identical responses. They reported that this would probably help reduce leadtimes if another raw materials shortage were to occur (38; 27). Two general points were brought out in discussing this topic with the forgers and others. First, this type of solution ties in with the availability of raw materials issue. If raw material availability is not a problem then making stockpile access easier will have little or no effect on leadtimes. However, if raw material availability is a problem then making access to the stockpile easier could have a significant impact on leadtimes. Secondly, if rotation of the stockpile becomes a reality then this solution will become a moot point. Rotation will accomplish making access easier (38).

Increase Domestic Raw Materials Production. This involves increasing U.S. and Canadian production of critical forging materials (titanium, cobalt, chromium). In addition to the forgers, information was obtained from an interview with RMI Company. ALCOA reported that this has been accomplished. In fact, they believe it has been accomplished to such a large degree that they do not feel they need to integrate into raw material production (10). Wyman-Gordon reported that domestic raw material production has been increased. In regards to its firm, it has integrated into titanium production by acquiring approximately 80 percent of International Titanium. It brought out that the cobalt problem has been lessened through

the use of alloys such as RENE-95 which use less cobalt than other common alloys (38). Ladish reported that it also thinks domestic raw materials production has been substantially increased. It reported that it has been integrated with Oremet, a titanium producer, for several years. Ladish pointed out that the non-existence of domestic cobalt capacity has been lessened through the use of high temperature alloys which do not require cobalt, for example INCO-718 (35). Kropp also reported that this has been done. However, it thinks there is still a shortage of vac-melt capacity (a process by which ingots or billets are produced from raw material) (27). RMI reported that domestic raw materials production has been greatly expanded. It reported that considerable amounts of excess capacity now exist in the domestic titanium industry (Chapter IV, p. 60, 66; Figure 10) (36). Two overriding points were made by the firms and individuals interviewed. First, titanium shortages are a solved problem. Domestic producers alone have more capacity than the U.S. aerospace market would require in another surge such as that of 1979-81 (Chapter IV, 60). And second, the cobalt problem still exists, but may have less effect on domestic forgers due to the substitution of alloys, such as RENE-95 and INCO-718, which use less, or no cobalt. The chromium problem also still exists but research is underway to develop alloys less dependent on that metal.

Increase The Use Of Near Net Shape Technologies. This primarily involves hot die forging, isothermal forging and hot isostatic pressing (HIPping) (Chapter II, p. 32-33). The responses of the four forging firms interviewed vary greatly in regard to this topic. ALCOA reported that it has significantly increased its use of these technologies since the 1979-81 period. It reported that the decision to invest in and use these technologies is completely economic and tied to the cost of raw materials. When raw

materials prices are high there may be an economic advantage to using hot die forging, isothermal forging or hot isostatic pressing processes, because they use less raw material than standard processes. However, when raw materials costs are down, as at the current time, then the savings in raw materials costs may be outweighed by the high cost of the specialized equipment required. In regards to saving time, ALCOA reported that near net shape technologies may, in fact, increase leadtimes. This is because, according to ALCOA, near shape technologies usually require more dies and more press operations than standard forging processes. The time saved in machining and finishing the part may be outweighed by the additional press time. The last point brought out by ALCOA concerns the adverse effect near net shape processes have on press capacity. The additional press operations required in near net shape processes reduces the available press capacity. If press capacity is a bottleneck (as some, but not ALCOA, believe), then it would be better to use standard procedures and conserve press capacity (10). Wyman-Gordon reported that it is extensively involved in hot die forging, isothermal forging and hot isostatic pressing. It concludes that these processes will reduce raw materials requirements and save money. It pointed out, that some materials cannot be formed any other way (38). Ladish reported that it has been involved in isothermal forging since the 1950's. In fact it had the first domestic isothermal forging capability. However, Ladish reports it is not currently involved in hot isostatic pressing and does not intend to become involved. It pointed out that there are some technical problems involved with HIPping which have not yet been resolved. Specifically, the metal flow is not as controllable or as consistent as with other methods. What happens quite often with HIPping is that the HIPped part is used as a preform. It is produced through the HIPping process to get

an intricate or difficult shape and then it is conventionally forged in order to get the consistent metallurgical properties demanded of forgings (35). Kropp reported that it is not involved in either isothermal forging or hot isostatic pressing at this time because the cost to do so is simply too high. It also thinks these processes are tied to the economics of raw material supplies (27).

One beneficial side effect of near net shape technologies is the fact that they generally reduce the time required to train workers. Essentially all of the state of the art forging equipment used in near net shape technologies is computer or numerically controlled. Instead of training an intricate skill, which only time and practice can bring about, forgers need only train the operation of the machine. As more and more state of the art equipment goes into service, the problem of 6 to 12 month time lags to expand labor forces will decrease.

Increase The Use Of Computer Aided Design (CAD) And Computer Assisted Manufacturing (CAM). This simply involves the addition and use of CAD/CAM equipment. The goal of which is to reduce leadtimes by reducing the time required for the design portion of the forging process. In addition to the forgers, information on CAD/CAM was obtained from an interview with Dr. Harold Gegel, Senior Scientist, Processing and High Temperatures Branch, Materials Lab, AFWAL/ML. Three of the forgers interviewed, ALCOA, Wyman-Gordon, and Ladish, gave essentially the same response on this topic. ALCOA reported that it has been involved in CAD/CAM for several years and has installed a new CAD/CAM system since 1981 (10). Wyman-Gordon reported that it has been involved in CAD/CAM for several years also (38). And Ladish reported that it is currently installing and beginning to use its CAD/CAM system. All three firms reported that they

expect CAD/CAM to reduce design time significantly. The reason being that information can be passed back and forth between the customer and forger, electronically, in a manner of minutes instead of the days the mail system used to take. They all brought out the belief that the tryout process could be reduced or eliminated by CAD/CAM. In other words, instead of producing dies and physically trying them out on the presses to make corrections, CAD/CAM has the potential to design and produce dies which will make a good part the first time, without corrections. They could skip steps and save both time and money. They all reported that this reduction in design time would probably result in leadtime reductions for customers (38; 10; 35). Kropp's response was somewhat different. First, it reported that, due to the current excessive cost of CAD/CAM systems, it is not involved in CAD/CAM at this time. Second, Kropp reported that if it was presently operating at a profit it would invest in a CAD/CAM capability. Third, it pointed out that even though a CAD/CAM system would reduce its design time it would have no effect on customer's leadtimes. Kropp's explanation is that it can design, produce, tryout, and correct its dies before it receives raw material for an order. It reported its raw material leadtime to currently be 10 to 12 weeks. Therefore, it contends that no matter how much design time is reduced it cannot forge the first part until the 10th or 12th week, when the raw material arrives (27).

Dr. Gegel, of ASD, reported that CAD/CAM is absolutely necessary to keep up and compete in the forging industry today. He brought out the point that many prime contractors are now requiring their forging sub-contractors to be CAD/CAM equipped (22). In this way, they not only save time in transferring information but they increase the accuracy of that information because it goes directly from computer to computer without

having to be reinterpreted and manually input.

Allow More Flexible Profit Margins On DOD Contracts. What this involves is allowing the DOD to pay higher levels of profit in order to be able to compete for forging capacity with commercial customers. The responses on this topic were identical for all four forgers interviewed. They all reported that it was a totally absurd concept in regards to forgers because there is no difference between commercial and DOD profit margins; every order is a commercial to the forgers (Chapter IV, p. 42). It may be a viable concept in regards to primes but not for sub-contractors (38; 10; 27; 35).

Air Force Systems Command Industrial Modernization Incentives Program (IMIP). This was one area which was scarcely covered in the literature on forging leadtimes and therefore not specifically included in the interview guideline. However, it was consistently brought to the interviewer's attention by the forgers. Information on IMIP, or Tech Mod as it is referred to at Aeronautical Systems Division was obtained from interviews with three individuals at Wright-Patterson AFB, Ohio; Dr. Harold Gegel, Senior Scientist, Processing and High Temperatures Branch, Materials Lab, AFWAL/ML; Captain Michael F. Theeck, Tech Mod Program Manager, Industrial Base Division, Directorate of Manufacturing and Quality Assurance; and 1st Lieutenant Edward M. Rogers, U.S. Forging Industry Tech Mod Program Manager, also of the Industrial Base Division, Directorate of Manufacturing and Quality Assurance.

The following paragraph from the Aerospace Industrial Modernization Office's publication, Air Force Systems Command Industrial Modernization Incentives Program Technical Review, sums up what IMIP/TECH MOD is and where it is used.

The Industrial Modernization Incentives Program (IMIP) is a joint venture between the government and industry to accelerate the implementation of modern equipment and management techniques in the industrial base. IMIP is a DOD program evolving from Air Force Technology Modernization (TECH MOD) and Army Industrial Productivity Initiatives (IPI) programs. IMIPs are implemented where competitive market forces are insufficient to bolster independent contractor modernization. They are also implemented where significant benefits such as cost reduction, elimination of production bottlenecks, improved quality and reliability, and improved surge capability can be expected to accrue to the government (40:1).

Captain Theeck and 1st Lt. Rogers reported that the government and contractors share the cost to analyze the firm's facilities, identify potential modernization projects, design, demonstrate and then implement these projects. According to Capt Theeck and 1st Lt. Rogers, the government does not pay for capital improvements, such as production equipment or brick and mortar changes to the contractor's facility. What the government will pay for is a portion of the cost to design the most promising candidate projects for implementation (43; 37). Dr. Gegel pointed out that customized computer software is one example of what the government might pay for. This is especially true in the case of CAD/CAM implementation (22).

Captain Theeck and 1st Lt. Rogers also pointed out that the technologies being implemented may not be new; IMIP is not a research and development program. It is designed to get existing manufacturing technologies implemented into firms which, for various reasons, would probably not make the investments on their own. While the technologies themselves may not be new, they may in fact be new to the particular industry into which they are being implemented. Therefore, one prime benefit is the potential to create a foothold for technologies new to a specific industry (43; 37). This is possible because as Captain Theeck and 1st Lt.

Rogers pointed out and as stated in Aeronautical Systems Division's publication, Industrial Modernization Incentives Program: A Guide To Technology Modernization And Contracting For Productivity:

Although a Tech Mod may be pursued with an individual contractor, the approach used and the technologies developed are considered public information. If the Tech Mod is funded by the Air Force, the data rights belong to the government, and the technologies are available for transfer throughout the U.S. industrial base (45:19).

According to 1st Lt. Rogers five aerospace forging companies are currently involved in the program. They are Aluminum Forge Company (Santa Ana, CA), Arcturus Manufacturing Corporation (Oxnard, CA), Chen-Tech Industries Inc. (Irvine, CA), Ladish Company: Pacific Division (Los Angeles, CA), and Ontario Forge Corporation (Muncie, IN) (37). Of the forging companies interviewed, only Ladish's Pacific Division is involved in this TECH MOD program. These companies are just now entering the detailed design, development and demonstration phase according to 1st Lt. Rogers (37).

The general opinion of most of the forgers interviewed was best summed up by one forger who stated "If you're going for Tech Mod you have to bear your soul to everybody. You have to tell everybody, so its better to use your own funds to develop something and keep it internal." The companies interviewed generally did not feel Tech Mod would have any substantial affect reducing leadtimes. The cost to them of having to open their doors to DOD more than offset any benefit from being involved. However, the fact that five forging companies are involved in the TECH MOD program is evidence that this opinion is not universal throughout the industry. Likewise, the Air Force representatives that were interviewed think that TECH MOD in the forging industry is definitely worthwhile. Dr.

Gegel thinks that CAD/CAM is an absolute must for every firm in the aerospace forging industry (22). 1st Lt. Rogers thinks that because of the potential for widespread acceptance and/or introduction of new technologies into the aerospace forging industry leadtimes could be reduced (37).

V. Findings, Conclusions, And Recommendations

Chapter Overview

This chapter is divided into three sections. The first section contains the conclusions drawn from the research in regards to the four general objectives of the study as stated in Chapter I (p. 2). The second section contains additional observations from the research which do not directly apply to any of the four general objectives. And finally, the third section contains suggestions for future research in the area of the forging leadtimes and the forging industry.

Research Objective Conclusions

The four research objectives, as stated in Chapter I, are:

- 1) Determine and define the current condition of the forging industry in relation to leadtimes.
- 2) Determine and define the probable causes responsible for past and present long leadtimes.
- 3) Determine, explain, and evaluate some possible solutions to causes of long leadtimes, both past and present.
- 4) Determine the causes for, or actions responsible for, current leadtimes: Are current leadtimes a result of action being taken to correct the proposed problems and/or causes and to implement the proposed solutions, or are they the result of purely market forces?

Determine And Define The Current Condition Of The Forging Industry In Relation To Leadtimes. The leadtimes to deliver aerospace forgings in 1986 are substantially reduced from those experienced in the 1979-81 period. In

1981 leadtimes were excessive, there was a shortage of skilled labor, and there was work available for all the forgers interviewed. In 1986 leadtimes are back to what the interviewed forgers consider a normal level, there is no current labor shortage, and there is not enough work available for all forgers. The data shows, that while leadtimes themselves have improved, the condition of the forging industry overall is much worse in 1986 than it was in the 1979-81 period. Overall industry employment has steadily declined and is now at a fraction of the 1979-81 level. Industry sales have significantly decreased. Imports are steadily increasing, capturing more and more of the commercial forgings market each year. Competition in the aerospace forging market has become increasingly fierce as a result of firms turning to DOD work as a way to escape import competition, and declining sales levels. Profit margins have declined, due to competition and slumping sales. Capital expenditures, to either modernize or increase production capacity, have fallen off sharply since 1982 as a result of low sales and smaller profit margins. The number of firms has decreased significantly, as the approximately 76 firms which have gone out of business since 1980 reflects. No large aerospace forgers have closed their doors yet, but, in the opinion of this researcher, this could occur in the near future. And finally, the data shows, aerospace forging firms have become more and more dependent on DOE business. The minimum dependence on combined DOD orders, among the interviewed forgers, is now 40 percent. This makes aerospace forgers more vulnerable to fluctuating DOD purchasing than they were in the 1979-81 period. To sum up, in nearly every aspect except actual time to deliver forgings, raw materials availability, and available capacity, the forging industry is in worse shape in 1986 than it was in 1979-81.

Determine And Define The Probable Causes Responsible For Past And Present Long Leadtimes. Fourteen problems or causes were identified as possibly being responsible for, or contributing to, excessive leadtimes and discussed with the four forgers and others. Again, the problems or causes are:

- 1) Lack of capacity
- 2) Lack of skilled labor

Raw materials availability:

- 3) Titanium
- 4) Cobalt/Chromium

Defense priorities and allocation system (DPAS) misuse or non-use:

- 5) Materials allocation portion
- 6) Production priorities portion
- 7) Mismanagement of the stockpile of strategic materials
- 8) Single year government funding
- 9) Military specifications
- 10) Supplier qualification requirements
- 11) OSHA and EPA regulation
- 12) Inefficiencies caused by the use of government owned plants and equipment
- 13) Imports
- 14) Offsets

The research shows that, each of these fourteen problems or causes can be put into one of the following four categories; 1) was not a leadtime problem in 1979-81 and is not today; 2) was not a leadtime problem in 1979-81 but is today; 3) was a leadtime problem in 1979-81 but is not today; and finally, 4) was a leadtime problem in 1979-81 and still is today.

Problems or causes which were not leadtime problems in 1979-81 and are not today are DPAS misuse or non-use, single year government funding, military specifications, supplier qualification requirements, OSHA and EPA regulations, and inefficiencies caused by GOCO's. DPAS was not, and is not, a leadtime problem because the forgers all use it and almost no orders have ever needed to be bumped, even during the 1979-81 period. Cases of firms not abiding by the DPAS are few and far between. Single year funding was not, and is not, a leadtime problem because, as the data shows, the number of parts ordered over the total life of most individual DOD programs is not enough to justify additional capital and labor force expansions. Military specifications were not, and are not, a leadtime problem because, as the research shows, there is no difference between commercial and DOD specifications; they are the same and they are necessary to produce parts of the required quality and reliability. Supplier qualification requirements were not, and are not, a leadtime problem because forgers are sub-contractors who deal directly with prime contractors or other higher tier sub-contractors, not the DOD. OSHA and EPA regulations were not, and are not, a leadtime problem. The data shows that, compliance can be costly; it can be inconvenient; but, it is usually justified and does not increase leadtimes. Finally, government owned and contractor operated plants and equipment were not, and are not, a leadtime problem because, the data shows that, the plants and equipment were not, and are not, antiquated, inefficient, or poorly maintained.

Problems or causes which were not leadtime problems in 1979-81 but are today include imports and offsets. The research found that imports are now a problem because they are gaining a larger and larger share of the U.S. commercial forgings market each year. This is either driving smaller firms

out of business or driving them into the DOD aerospace markets were there is currently greater safety from import competition. For firms already in the aerospace markets, imports are cutting into and threatening their commercial operations, as in the case of Wyman-Gordon's recently closed Harvey, Illinois crankshaft plant. The overall affect of imports on the total aerospace forgings market is increased competition from additional firms, correspondingly lower sales and profit margins for individual firms, and an increased dependence on volatile defense production as the percentage of business that is commercial, declines. From the data received, offsets are only now a problem because the practice was rarely seen prior to 1980. Every forging produced offshore, as part of an offset arrangement, directly reduces sales, profits, and labor requirements of domestic forgers and creates additional excess capacity.

Problems or causes which were leadtime problems in 1979-81 but are not today are lack of capacity, raw materials availability, both titanium and cobalt/chromium, and mismanagement of the stockpile of strategic materials. There was a lack of capacity in certain types of forging equipment during the 1979-81 period. However, what specific type of equipment there was a lack of capacity of, varied from forger to forger. For one it was large press capacity; for another it was preform capacity; and, for others it may have been die sinking equipment. The fact is that the excessive surge in both military and commercial aircraft orders, which flooded domestic aerospace forgers in the late 1970's, created a serious backlog and caught the industry off guard. No forging firm was, or could have been, completely prepared in every area of forging production. However, capacity in the forging industry is not a problem which extends leadtimes today. Many new large presses, as well as all other types of forging equipment, have come into operation since

1980. This fact, combined with the current low level of business in the industry, means that there truly is a great deal of excess capacity in the aerospace forging industry in 1986. Raw materials availability was the single worst problem which extended leadtimes in the 1979-81 period. However, it is no longer a leadtime problem for most forgers, and it is the single greatest example of successful solving of one of the 1979-81 leadtime problems. Average titanium delivery in 1986 is approximately one fourth the average time required in 1980-81 (52 weeks vs. 8-12 weeks). Not only is there currently large amounts of excess capacity in the titanium industry, there is more than enough capacity in the U.S. alone to handle another surge the equal of the 1979-81 period. Cobalt availability is no longer extending leadtimes. The increased useage of alloys which use less, or no cobalt, has reduced the dependence on it or its politically unstable sources of supply. Chromium availability is currently not a problem because of the low level of business in the industry, and ongoing research may also reduce dependence on it or its politically unstable sources of supply. And finally, alleged mismanagement of the stockpile of strategic materials is no longer a problem which lengthens leadtimes. Releases of stockpiled materials could have alleviated, or reduced, some of the raw materials shortages during the 1979-81 period. However, with the raw materials problem itself now solved, changes in the management of the stockpile of strategic materials will have little or no affect on the leadtimes to deliver forgings.

Problems or causes which were leadtime problems in 1979-81 and still are today consists only of the lack of skilled labor. Not only was the time to train and bring new workers up to speed excessive in 1979-81 (6 to 12 months), it still is today. In fact, the potential for leadtime problems is greater today than in 1980. Because of the current poor economic condition

of the forging industry, employment levels are only 50 percent of the 1979-81 levels. A production surge today, such as that of 1979-81, could cause a greater training problem and labor shortage than occurred in 1979-81.

Determine, Explain, And Evaluate Some Possible Solutions To Causes Of Long Leadtimes, Both Past And Present. In response to the fourteen possible problems identified, fourteen possible solutions were identified and reviewed with the four forgers and others interviewed. Again, the possible solutions are:

- 1) Multi-year funding (whole program & flowed down from prime contractor to the forger)
 - 2) Component multi-year funding (direct multi-year contract for a single component, whole program not on multi-year)
 - 3) Income tax credits for capital expansion investments and/or increased depreciation allowances on new capacity and new technology
 - 4) "Up front" purchases of spares
 - 5) Eliminate government owned and contractor operated (GOCO) plants and equipment
- Make better use of the Defense Priorities and Allocations System (DPAS)
- 6) Materials allocation portion
 - 7) Production priorities portion
 - 8) Rotate national stockpile of strategic materials
 - 9) Make stockpile access easier
 - 10) Increase Domestic raw materials production
 - 11) Increase the use of near net shape technologies
 - 12) Increase the use of Computer Aided Design (CAD) and Computer Assisted Manufacturing (CAM)

- 13) Allow more flexible profit margins on DOD contracts
- 14) Industrial Modernization Incentives Program (IMIP)

Of these fourteen solutions, eight are intended to reduce leadtimes by attacking the perceived lack of capacity problem; four are intended to reduce leadtimes by attacking the perceived raw materials availability problem; and the remaining two are intended to reduce leadtimes by attacking other perceived problems. One important point needs to be brought out before going any further. There is a very basic flaw in the eight possible solutions which are aimed at attacking the lack of capacity problem. This is the fact that forgers had mixed opinions as to whether capacity was a problem in the 1979-81 period and essentially no forgers view capacity as a current problem. Eight of the thirteen identified solutions are intended to solve a problem which forgers do not view as a problem in the first place. The probability of these eight solutions ultimately leading to the intended goal of increasing capacity is, therefore, very low.

Solutions Aimed At The Lack Of Capacity Problem. The eight lack of capacity solutions are; 1) multi-year funding, 2) component multi-year funding, 3) income tax credits and increased depreciation allowances for capital investments, 4) "up front" purchases of spares, 5) elimination of GOCO's, 6) increased use of near net shape technologies, 7) increased use of CAD/CAM, and 8) IMIP. Multi-year funding will not increase capacity as intended because the vast majority of the benefits from multi-year contracts affect only the prime contractor. Even if the prime flows all the multi-year benefits to the sub-contractor forger, the small number of parts, the small percentage of any given forgers business made up by a single DOD program, is too small to affect the investment decisions of the forging firm. The situation is nearly identical for component multi-year. The only difference is

that all the benefits of multi-year contracts are, in fact, recieved by the forger. But again, the small number of parts and small percentage of total business made up by any one program is not enough to influence capital expansion decisions. Multi-year funding is becoming more common due to successes with it saving money, but not because it leads to increased capacity. Component multi-year, as far as the researcher was able to determine, is still only a good idea. It has not yet been used for the purchase of forgings from any of the firms interviewed.

Income tax credits and increased depreciation allowances for capital expansion expenditures also appear to merely be good ideas. The data did not reveal any additional credits or increased allowances that had been introduced since 1980 to aid forgers. If additional credits or allowances had been introduced, the data suggests that it is highly unlikely they would have been substantial enough to influence the capital expenditures of firms who do not see capacity as a problem. Forgers are glad to have these types of tax breaks but they only see them as "icing on the cake" for expenditures they would have made, or will make, anyway.

The purchase of spares "up front", as a means to inject additional cash into a forging firm, will also fail to induce capital expenditures. Because of the small number of total parts involved in most DOD programs, the number of additional parts purchased as spares will not be significant. The relatively small amount of additional cash from one, or even a few, programs will not induce a firm to invest in any additional capacity they would not invest in without the additional spares purchase. No firm interviewed reported having experienced the "up front" purchase of spares, and as sub-contractors may not realize if an order includes additional numbers as "up front" spares.

Elimination of government owned and contractor operated plants and

equipment has been accomplished to a very large degree throughout the forging industry. However, it has not resulted in the replacement of the original forging equipment as intended. Forgers do not see their newly obtained, from the Government, assets as something which needs replacing. These assets are generally being maintained in much the same manner as when they were DOD assets.

Since 1980 there have been increases in the use of near net shape technologies and associated equipment. This primarily involves hot die forging, isothermal forging and hot isostatic pressing. All three technologies have the potential to save time, raw material, required labor, and money. However, these technologies are "state-of-the-art" production methods, and as such, are in many ways still in their infancies and not yet perfected. There are problems which cause some firms to resist investing in them until they are more thoroughly proven. To acquire the capability to produce forgings with these technologies still requires extensive capital investments, especially in view of the current depressed economic condition of the forging industry. Therefore, despite the potential for time, material, labor, and monetary savings, the use of these technologies is not as wide spread as the DOD and other non-forger users would like.

There have been significant increases in the use of Computer Aided Design and Computer Assisted Manufacturing (CAD/CAM) since 1980. CAD/CAM is almost a necessity in the aerospace forging industry today due to many prime contractors requiring this capability of their sub-contractors. The potential for time, labor, and monetary savings is substantial. As one forger put it "we are just at the tip of the iceberg in CAD/CAM. It's got a tremendous way to go" (38). CAD/CAM is still expensive but, due to the general reduction in cost of most computer products, the cost has dropped a

great deal since 1980 and put it within reach of most aerospace forging firms.

The last of the eight solutions aimed at the capacity problem is IMIP, or Tech Mod as it is referred to at the Air Force's Aeronautical Systems Division. The program currently involves only five aerospace forging companies. The largest firms are not involved and the interviewed firms did not appear likely to become involved. The interview information suggests that due to its small size it will not significantly reduce leadtimes. The forging industry Tech Mod program manager, 1st Lt. Edward M. Rogers, would disagree with this assessment based on IMIP's potential for introducing new technologies to the forging industry and the opportunity for other forging companies to access the detailed design information at very little cost (37).

Solutions Aimed At The Raw Materials Problem. The four solutions aimed at the raw materials problem are; 1) rotation of the stockpile of strategic materials, 2) making access to the stockpile of strategic materials easier, 3) increasing domestic raw material production, and 4) making better use of the materials allocation portion of the DPAS.

In general, rotation of the stockpile is not occurring, although the entire stockpile program policy is currently under review (24). If stockpile rotation does take place it will not reduce leadtimes due to the fact that raw materials are no longer a problem. However, elimination of obsolete material currently in the stockpile would essentially be assured.

Making access to the stockpile easier has essentially been done. According to the Department of Commerce all that is required is the President's approval. However, because raw material availability is not a current problem, reductions in leadtimes will be nonexistent. The benefit will be to insure that in another surge the stockpile is actually used, unlike

in 1979-81, to alleviate as much of the disruption in the delivery of raw materials as possible.

The last solution aimed at the raw materials problem is to make better use of the materials allocation portion of the DPAS. The materials which are critical to aerospace forgings (titanium, cobalt, and chromium) never have been included and probably will not be included. The problem has been getting them into the U.S., not allocating them to the proper industries. These materials are now either in plentiful supply or dependence on them is being reduced by using alloys which require less of them. None of these materials are currently extending leadtimes. Therefore, suggestions have been proposed to eliminate this portion of the DPAS because it is serving no useful purpose (31).

Solutions Aimed At Other Problems. Two of the identified solutions fall into this category, allowing more flexible profit margins on DOD contracts and making better use of the production (or contract) priorities portion of the Defense Priorities and Allocations System (DPAS). The data revealed that, allowing more flexible profit margins is a concept which would not affect forgers and, therefore, would be ineffective if implemented. It would be ineffective because this solution is designed to combat commercial customers outbidding the DOD for forging capacity, which does not occur. Forgers do not deal directly with the DOD so there is also no way to assure they would ever receive any additional profits. Making better use of the production priorities portion of the DPAS could reduce leadtimes for some products if, in another surge, enforcement was stepped up. However, the vast majority of forgers already use and abide by the provisions of the DPAS. The possibility for significant leadtime reductions would be if, in a national emergency, the provisions of the DPAS were used to preempt commercial

production regardless of whether the contract deadlines for DOD items could be met without bumping commercial orders. At the present time, better use of the production priorities portion of the DPAS will not reduce leadtimes because excess capacity exists throughout the industry.

Determine The Causes For, Or Actions Responsible For, Current Leadtimes: Are Current Leadtimes A Result Of Action Being Taken To Correct Problems And Implement Solutions, Or Are They The Result Of Market Forces? With only one exception, everyone interviewed, forger and non-forger, stated that they believed market forces were primarily responsible for current forging leadtimes. Market forces, not actions to correct problems or implement solutions, are primarily responsible for current leadtimes, which average approximately 28 weeks.

Since 1980, the commercial sector (the forging industry and the titanium and raw materials industries) has been responsible for the following: 1) the addition of new forging capacity including several large presses, 2) increased capacity in titanium to the point where the U.S. is now self sufficient in sponge production, 3) less dependence on cobalt, 4) increased use of near net shape technologies such as hot die forging, isothermal forging and hot isostatic pressing, and 5) increases in the use of CAD/CAM. Since 1980, the government sector (the DOD and the Department of Commerce) has been responsible for the following: 1) consolidation of the old Defense Priorities System (DPS) and Defense Materials System (DMS) into the new Defense Priorities and Allocations System (DPAS), 2) selling forgers much of the government owned and contractor operated equipment in the forger's plants, 3) increased use of multi-year contracts, 4) a current reviewing of the entire stockpile program policy, and 5) implementation of the Industrial Modernization Incentives Program.

Reductions in leadtimes as a result of these actions has been minimal, or is as of yet untested in any type of surge situation. Chapter IV discussed why the increased use of near net shape technologies, the increased use of CAD/CAM, the creation and better use of DPAS, the elimination of GOCO's, the increased use of multi-year funding, changes in the management of the stockpile, and the IMIP have had, or will have, little affect in shortening forging leadtimes. The other actions, increasing capacity and increasing raw materials availability, can reduce leadtimes. However, they have not had a noticeable impact because the increased capacity came online and the materials became more readily available during the current industry slump where sales are well below the 1981 levels. As a result, some of the new capacity, both forging and raw materials processing, became excess soon after it was put into operation. Therefore, market forces are apparently responsible for current leadtimes. Specifically, slumping sales levels well below the 1981 levels. The current level of sales would produce the same leadtimes currently being experienced with or without the actions mentioned above having taken place.

Additional Observations And/Or Conclusions

Five additional observations and/or conclusions from the research which seem to be especially significant and warrant discussion are:

- 1) There was substantial disagreement between the opinions of the firms interviewed and the information contained in the literature review. The interviewees essentially contradicted many of the conclusions in the literature.
- 2) Forgers do not think that they are as much to blame for leadtimes as many non-forgers think they are.

- 3) The current economic condition of the domestic forging industry makes it extremely difficult for non-forgers to convince forgers to expand and modernize their facilities.
- 4) The industry is much more vital to the well being of the technical infrastructure of the U.S. economy than its economic size implies.
- 5) The problems facing the forging industry are too complicated for any one body to attempt to solve by itself.

There Was Substantial Disagreement Between The Opinions Of The Firms Interviewed And The Information Contained In The Literature Review. The data presented in Chapter IV shows that the majority of problems and causes cited in the literature review as being responsible for, or contributing to, long leadtimes were not and/or are not perceived as problems by the interviewed firms. Likewise, the data shows that the majority of possible solutions cited in the literature review are not perceived by the interviewed firms as being viable for reducing forging leadtimes.

Forgers Do Not Think They Are As Much To Blame For Long Leadtimes As Some Non-Forgers Think They Are. The forgers interviewed think that they have done the best they can considering the economic condition of the industry over the past few years. With sales and profits down, and competition up, they think the responsibility attributed to them for long leadtimes is out of proportion. One individual summed this up best, as follows:

We think that we, we the forging industry, probably have been used as an excuse by some of the government prime contractors more often than they have the right, perhaps the need, to use us as an excuse or as a "whipping boy". We have seen, within the last couple of years, articles still in the press relative to the long leadtimes in the forging business. And frankly, those leadtimes are not very long today as we believe our capability to manage our business is.

The Current Economic Condition Of The Domestic Forging Industry
Makes It Difficult For Non-Forgers To Convince Forgers To Expand And
Modernize Their Facilities. This can best be summed up with a question.
 How do you convince a forging firm whose sales are down 35 percent, whose
 profits are down more than 50 percent, whose labor force is 50 percent of
 what it was five years before, is operating at 50 percent capacity, and has to
 answer to its stockholders that it needs to expand and upgrade its capacity?
 The answer is that you usually cannot, as Figure 8, presented again here,
 shows.

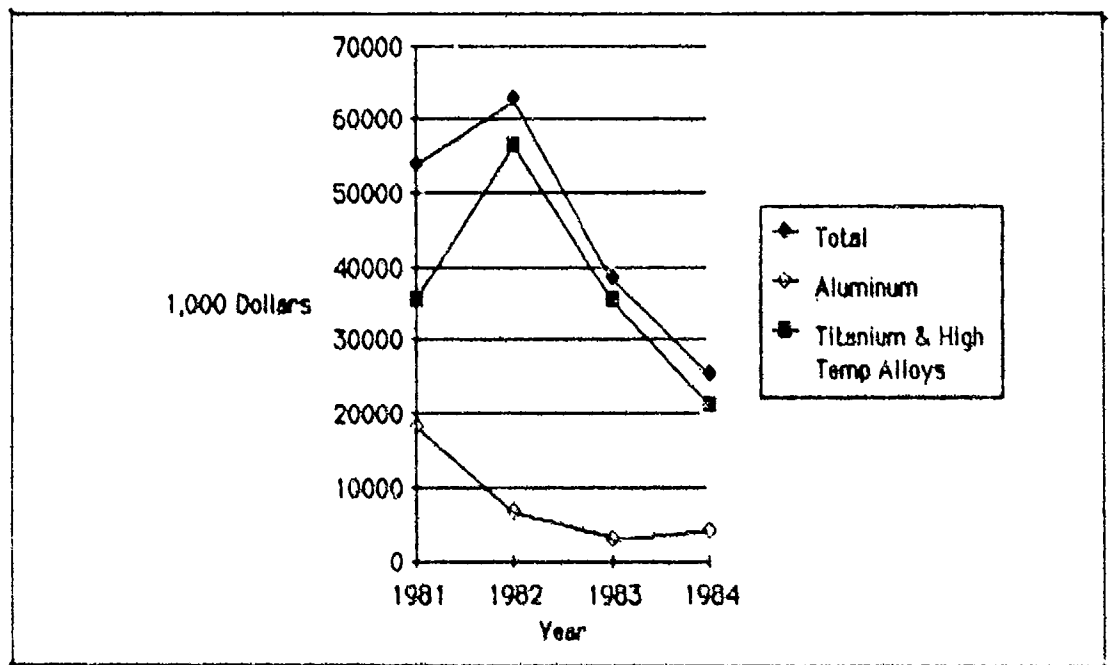


Figure 8. Capital Expenditures: Aluminum, Titanium,
 & High Temperature Alloy Forgers
 Adapted from USITC figures (48:21)

The Industry Is Much More Critical Technically To The Security Of The
U.S. Than Its Economic Size implies. The Statistical Abstract Of The United
States 1985, produced by the Department of Commerce, reported Gross
 Domestic Product (GDP) for 1983 (the most recent year figures were

available for) to be 2.3 trillion dollars (47:52). According to the USITC's Competitive Assessment Of The U.S. Forging Industry, total sales for the forging industry, aerospace and non-aerospace combined, were approximately 3.1 billion dollars in 1985 (48:19). Therefore, total forging industry sales amount to less than two tenths of one percent of Gross Domestic Product. The Statistical Abstract Of The United States 1985 reported the total number of employed workers in the U.S. in June of 1984 to be 107.4 million (47:390). The Competitive Assessment Of The U.S. Forging Industry reported total forging industry employment to be approximately 40,000 in 1985 (48:19). This amounts to less than four one hundredths of one percent of the total U.S. labor force. A decrease of 3 to 4 billion in GNP or the loss of 40,000 jobs is essentially insignificant economically compared with total Gross Domestic Product or the total labor force. However, the loss of U.S. forging capability would be very significant technically. Without the forging industry, as small as it is economically, it would be much more difficult for the U.S. to produce aircraft, missiles, spacecraft, automobiles, trucks, ships, farm equipment, or electrical power generation equipment, and the list goes on. The forging industry is one of the most vital basic industries technically in the U.S. and should receive attention based on that importance, not its economic size.

The Problems Facing The Forging Industry Are Too Complicated For Any One Body Or Organization To Solve By Itself. This final point was brought out by Brad I. Botwin, an economist for the Department of Commerce's Office of Industrial Administration. The economic problems threatening the forging industry and, therefore, U.S. forging capability, are too large and complicated for any one organization to handle alone. In order to solve the problems facing the forging industry the various organizations

involved (DOD, DOD prime contractors, Department of Commerce, Forgers, etc.) will need to work together. In fact, in order to avoid a further loss of domestic forging capability, some type of congressional involvement may be needed if the economic condition of the industry worsens (7).

Recommendations For Future Research

This study was descriptive in nature and very broad in scope. It identified and evaluated possible problems causing or contributing to long leadtimes in the forging industry and possible solutions to those problems. Additional research of a quantitative nature in any one of the identified problem or solution areas is warranted. The study basically involved only forgers. A similar study involving other groups, such as higher tier sub-contractors, prime contractors, or DOD contracting or procurement personnel is needed. Finally, it was brought out in one interview that the forgings industry is not the only technically critical basic U.S. industry in poor economic condition. Several other industries are, thought to be, in the exact same situation as the forgings industry (7). Specifically, the castings, bearings, titanium, steel, and machine tools industries could benefit from a similar study.

Appendix A. List of Firms Which Have Gone Out of Business Since 1980
Reprinted By Permission of the Forging Industry Association (F.I.A.) (2)

<u>LIST OF FORGING PLANT CLOSINGS SINCE 1979</u> <u>(Source: Forging Industry Association)</u>	<u>Estimated Job Losses</u>	<u>Year Forging Operations Believed to Have Ceased</u>
1. AmForge, Great Lakes Plant - Chicago, IL	238	1983
2. American Hoist & Derrick-Crosby Group - Lockport, NY	50	1985
3. American Hoist & Derrick-Crosby Group - Owensboro, KY	50	1983
4. Ashtabula Forge - Ashtabula, OH	262	1983
5. Atlas Forge (Dana Corporation) - Lansing, MI	280	1985
6. B & W Forge Div. - Beaver Falls, PA	50	1983
7. Baldt Anchor & Chain - Chester, PA	50	1984
8. Beaumont Forge - Beaumont, TX	10	1983
9. Beaumont Well Works, Ring Rolling Plant - Houston, TX	20	1984
10. Bethlehem R.R. Axle Forge Div. - Pennsylvania	50	1983
11. Bethlehem Steel - Lebanon, PA	50	1985
12. Bonney Forge - Bethlehem, PA	63	1983
13. Cameron Manufacturing, Forge Div. - Emporium, PA	150	1984
14. Canadian Chains - Skowhegan, ME	10	1982
15. Canton Drop Forge-Plant A - Canton, OH	104	1983
16. Century Brass Products - Waterbury, CT	100	1984
17. Clark Equipment - Jackson, MI	50	1980
18. Colorado Forge - Colorado Springs, CO	50	1984
19. Columbus Forge & Iron - Columbus, OH	50	1983
20. Conklin Forge - Detroit, MI	50	1983
21. Crescent Forge - Jamestown, NY	400	1983
22. Custom American Forge - McKees Rocks, PA	100	1983
23. Dallas Forge - Dallas, TX	120	1982
24. John Deere Forge - Moline, IL	100	1983
25. John Deere Forge - Waterloo, IA	50	1983
26. Dixie Alloys, Portec - Calera, AL	25	1984
27. Dresser Forge Div. - Johnson City, TN	130	1984
28. Easco - Springfield, MA	200	1985
29. Franklin Forge - West Branch, MI	94	1983
30. Gardner Denver Forge Div. - Denver, CO	500	1981
31. G.M. Chevrolet, Muncie Forge - Muncie, IN	25	1982
32. G.M. Oldsmobile, Lansing Forge - Lansing, MI	100	1980
33. Great Lakes Forge - Windsor, Ontario	85	1982
34. Heppenstall Co. - Pittsburgh, PA	1000	1979
35. Indiana Forge & Machine - East Chicago, IL	94	1982
36. Ingersoll-Rand - Jamestown, NY	345	1982
37. International Harvester Forge - Canton, IL	100	1981
38. International Harvester Forge - Ft. Wayne, IN	50	1982
39. International Harvester Forge - Louisville, KY	130	1985
40. Janney Cylinder - Philadelphia, PA	195	1985

<u>List of Plant Closings (cont'd)</u>	<u>Estimated Job Losses</u>	<u>Year Forging Operations Believed to Have Ceased</u>
41. Jersey Forging Works - Newark, NJ	50	1982
42. K.D. Tool & Forge - Chicago, IL	100	1981
43. Kyle Forge - Claremore, OK	15	1983
44. Manistee Forge - Manistee, MI	245	1985
45. Massey-Ferguson - Brantford, Ontario	100	1985
46. Millers Forge, Keene, NH	25	1980
47. Minnesota Forgings - Minneapolis, MN	10	1983
48. Napco Forge Products - New York, NY	50	1983
49. New England Forge - Massachusetts	50	1983
50. Nuclear Forge - Oklahoma	20	1983
51. Pettibone Forge Div. - Chicago, IL	150	1984
52. Philadelphia Iron & Steel - Conshohocken, PA	100	1981
53. Portec, Inc. - Canton, OH	130	1985
54. Pullman - Butler, PA	50	1981
55. Red Oak Forge - Red Oak, IA	60	1984
56. South Bend Forge - South Bend, IN	50	1984
57. Superior Hand Forging - Michigan	15	1982
58. Thorsen Tool - Dallas, TX	50	1985
59. U.S. Forge - Detroit, MI	119	1982
60. U.S.S. Forge Div. - Homestead, PA	1000	1984
61. U.S.S. R.R. Axle Forge Div. - McKees Rocks, PA	500	1985
62. Wagner Castings, Forging Div. - Decatur, IL	100	1981
63. Walco Forging Group, American Forge - Kinchloe, MI	25	1983
64. Walco Forging Group, Lansing Forge (Fed. Plant) - Lansing, MI	200	1982
65. Walco Forging Group, Owensboro Plant - Owensboro, KY	100	1981
	8,944	

Additional Plant Closings of Pipe Fitting Producers
(Source: American Pipe Fittings Association)

1. Bristol Metals - Bristol, TN	50	1984
2-5. Gulf & Western, 4 plant closings	775	1983
6. ITT Grinnell - Princeton, KY	300	1985
7. Mid Atlantic Flange - Philadelphia, PA	50	1984
8. Speedline Inc. - Philadelphia, PA	100	1982
9. Sunwell Fittings - Los Angeles, CA	50	1982
10. Tube Forgings of America - Portland, OR	160	1985
11. Waterman - Philadelphia, PA	50	1984
	<u>1,535</u>	

AGGREGATE ESTIMATED JOB LOSSES

10,479

Appendix B. Structured Interview Guideline

The DOD thought that leadtimes for aerospace forgings became excessive for the industry during 1979-80. During that time many studies were done and military and congressional people became very concerned. Several problems and problem areas were identified as being either direct causes of, or contributing factors to, long leadtimes. Additionally, some possible solutions to the problem or its suspected causes were put forth. Leadtimes for aerospace forgings today are not nearly as long as in 1980. The basic question I'm trying to answer is whether the changes, the improvements, are a result of purely market forces or have they been the result of action being taken to solve some of the problems and/or problem areas identified in the 1979-80 time frame.

FIA states that the average firm has less than 125 employees and less than 15 million in annual sales. This obviously isn't the case for forgers doing DOD aerospace work. The following questions will help me get a better idea of what the average size and profile of DOD forgers are. Wherever possible I would appreciate information by years, from 1977 to the present.

How many employees does your firm have?

Of these employees, how many are direct labor and how many are indirect labor employees?

What is the dollar value of your annual sales?

Of these sales what is the ratio of commercial to DOD items?

If possible, what is your firms profit margin?

Is there a difference in the profit margin for commercial versus DOD items, and if so what are the margins?

What is the average age of your various categories capital equipment (metal cutting, presses, hammers, heat treatment, etc)?

What would it cost you to either replace this equipment or add new capacity?

At what level of capacity have you operated and at what level are you operating today (number of shifts, utilization rate)?

At what level could you realistically operate at if necessary (3X8X5, 2X10X5, etc.)?

How much of your excess capacity could be used for DOD aerospace work if required? What would be the limiting factor(s)?

What specific OSHA and EPA regulations have impacted you the greatest and what has been their affect?

What specific products do you produce for eventual DOD use?

If for another DOD contractor, who is that contractor?

What are the current leadtimes for those products and what have they been in the past?

What is a typical flow process, for your firm, from initial order of a forging to first production run? What steps and processes occur, what is the time involved, and what is the cost of each step? (For example, initial product design, die production and testing, etc.)

The following are problem areas or factors which have been identified as responsible for, or contributing to, long leadtimes for DOD aerospace forgings. I'd like to know 1) if you agree or disagree, and why; 2) if your firm has experienced any of these, if so which ones, and the affect; 3) in your opinion are they still valid concerns ? Also, please mention any problems or concerns not listed below.

Lack of capacity

Technology

Capital equipment

Lack of capability

Lack of skilled labor

Raw materials availability

Titanium

Cobalt

Chromium

Defense Priorities System/Defense Materials System misuse or non-use

Mismanagement of stockpile of strategic materials

Single year government funding
Military specifications
Supplier qualification requirements
OSHA and EPA regulation
Inefficiencies caused by use of government furnished plants or equipment
Imports

The following are suggested solutions to long leadtimes. Again, I'd like to know 1) if you agree or disagree, and why; 2) if your firm has experienced any of these, if so which ones, and the affect; 3) in your opinion are they still valid solutions ? Also, please mention any solutions not listed below that you feel might be effective.

Multi-year funding (whole program & passed down from prime contractor)
Component multi-year funding (direct multi-year contract for a single component, whole program not on multi-year)
Income tax credits for capital expansion investments
Increased depreciation allowances
Up front purchase of spares
Eliminate gov't owned and contractor operated plants and gov't furnished equipment
Make better use of DPS and DMS
Rotate national stockpile
Make stockpile access easier
Increase domestic raw materials production
Increase use of near net shape technologies
Increase use of CAD and CAM

Appendix C. List of Interviewees

ALCOA Forging Division (Cleveland, OH)

Clyde R. Gillespie, Vice President-Engineered Products Group
Robert R. DeLay, Marketing Manager-Forging Division
Robert E. Stormer, Production Control Superintendent
Michael A. Peters, Works Chief Industrial Engineer
Clifford E. Kneblewics, Inspection Superintendent

Forging Industry Association (Cleveland, OH)

Robert W. Atkinson, Executive Vice President

Industrial Base Division, Directorate of Manufacturing and Quality Assurance, ASD/PMDI, WPAFB Ohio (Dayton, OH)

Capt. Michael F. Theeck, TECH MOD Program Manager
1st Lt. Edward M. Rogers, Forging Industry TECH MOD Program Manager
David Dilley, Group Leader Plans and Budgets

Kropp Forge Company (Chicago, IL)

Robert W. Kowske, Director of Sales

Ladish Company: Cudahy Forgings Division (Cudahy, WI)

Gregory L. Parker, Marketing Manager

Materials Lab, Processing and High Temperatures Branch, AFWAL/ML, WPAFB Ohio (Dayton, OH)

Dr. Harold Gegel, Senior Scientist

Office of Industrial Resource Administration, Department of Commerce
(Washington, DC)

Brad I. Botwin, Economist

Paul J. Halpern, Strategic Materials Program Manager

Richard V. Meyers, DPAS Program Manager

RMI Comapny (Niles, OH)

Crystal L. Revak, Manager-Marketing Communications

The Dayton Forging & Heat Treatment Company (Dayton, OH)

Harlan H. Todd, President

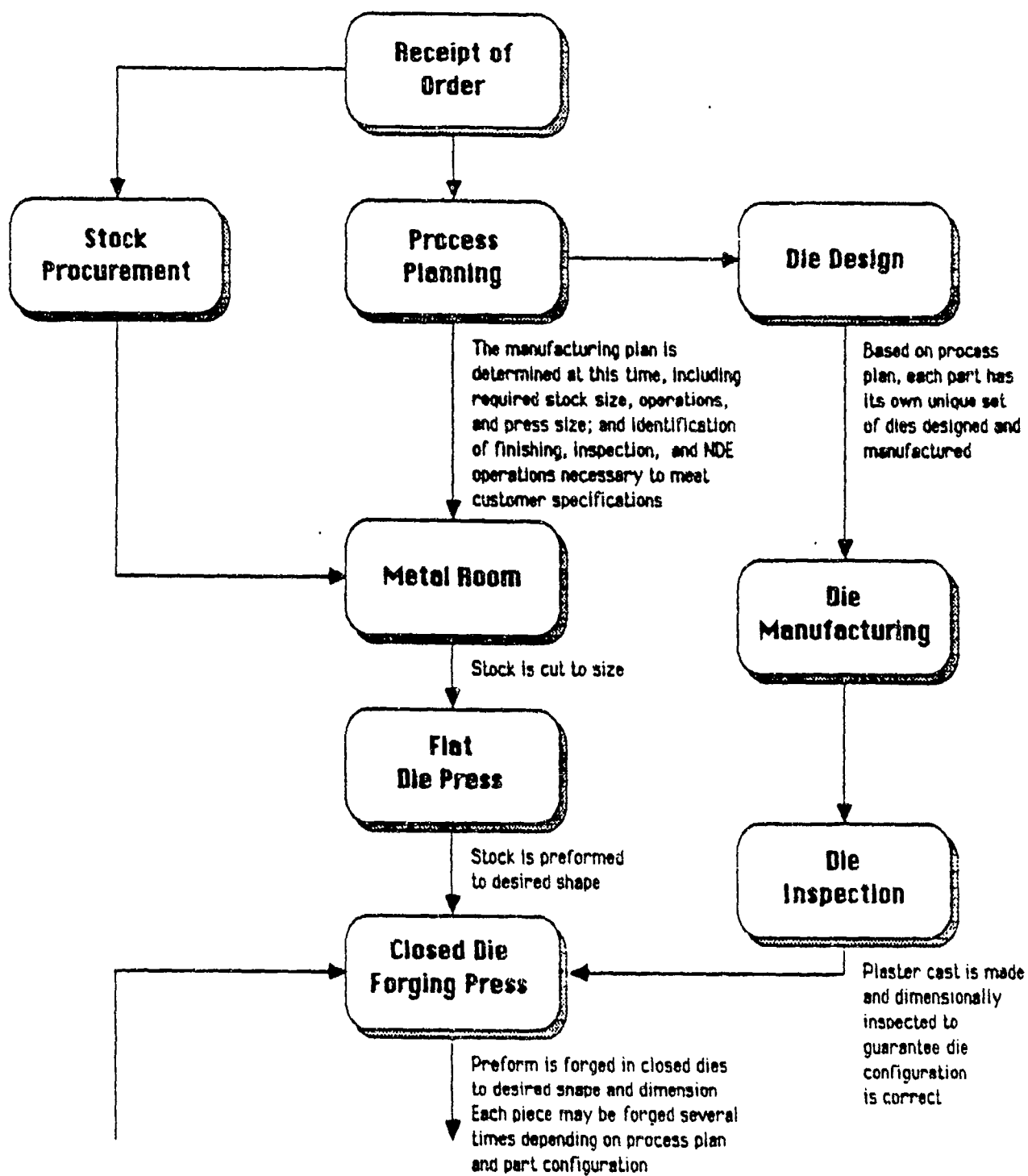
Ken Amick, Director-Management and Labor Relations

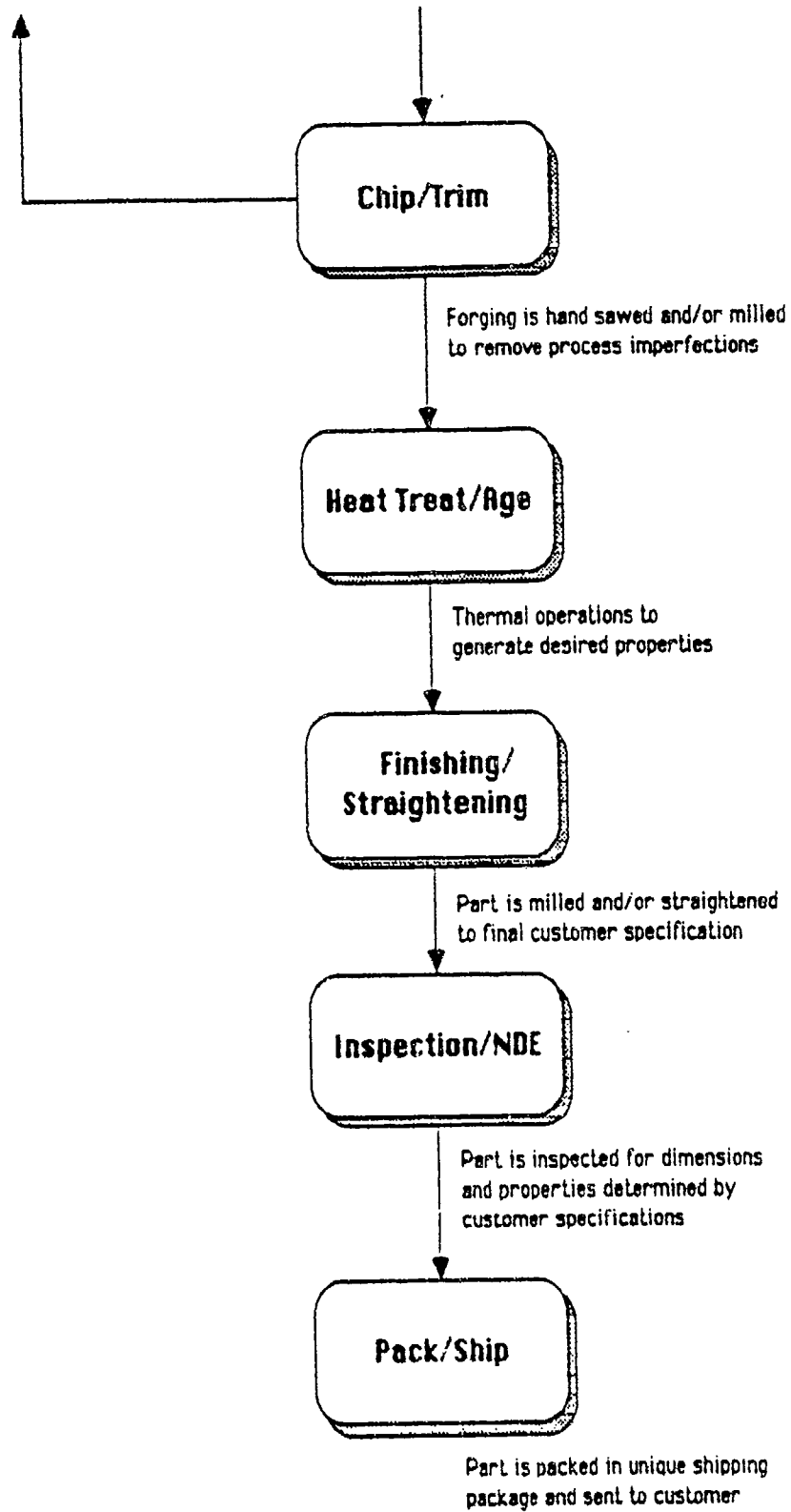
Wyman-Gordon Company: Eastern Division (Worcester, MA)

Robert F. Rotondi, Manager-Market Research and Development

Michael M. Gumma, Director of Marketing and International Sales

Forging Process Description





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Leadtimes for aerospace forgings exceeded two years, in some cases between 1979 and 1981. While current leadtimes are not this long, there remains concern over the leadtimes for forgings and the forging industry's ability to respond to increased demand in a timely manner. A review of literature pertaining to this topic was conducted and is included in this report. Possible problems and/or causes responsible for long forging leadtimes, and possible solutions to long forging leadtimes, were identified from the review of literature. Interviews were conducted, concerning the identified problems and solutions, with forging firms, forging industry officials, raw materials processors, USAF personnel (active duty and civilian), and Department of Commerce personnel. The results of those interviews and conclusions drawn from them concerning the identified problems and solutions are presented.